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THE GLASS INDUSTRY

THE JOURNAL OF GLASS MANUFACTURING

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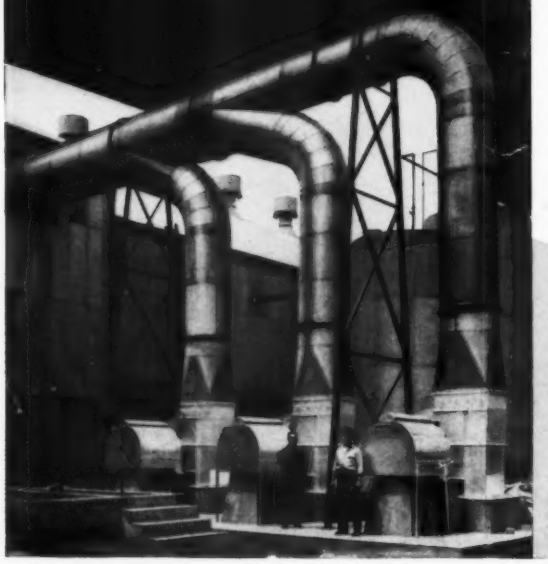
Oscar Burch: 1961 Toledo Award Winner

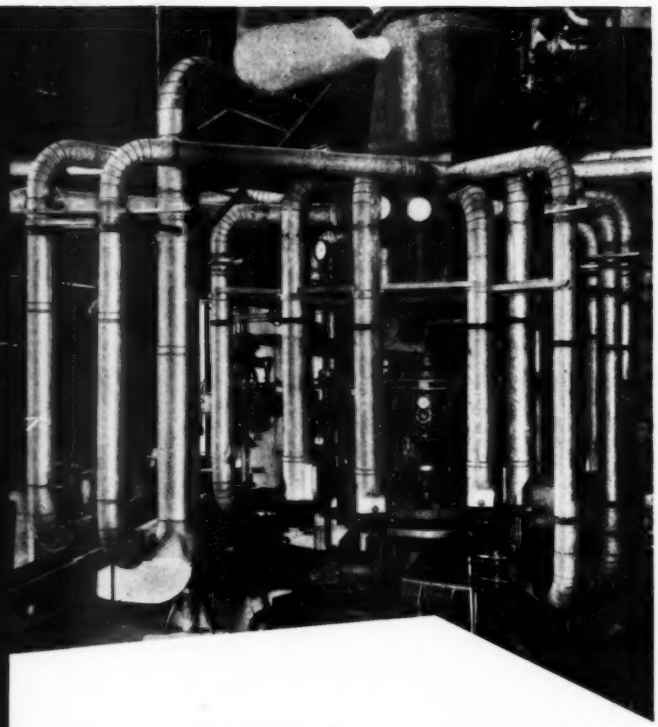
$25,000 PROBLEM:

pressure IN
-pressure OUT

= Lost Power Dollars

SIMPLE ARITHMETIC...BUT VITAL TO YOUR COSTS!





$25,000 per year is the approximate power cost of a typical furnace and machine cooling system in container plants.

This power cost is directly reflected in terms of pressure produced at the fan outlet—double the pressure, double the power cost. Discharge pressure at the cooling nozzle orifice measures results accomplished by good design.

This differential should not generally exceed 1½" W.G. System efficiency can be determined in a few minutes by measuring these pressures. You can do it yourself with simple equipment.

If you find a 50% loss of pressure between the fan outlet and the nozzle orifice, it means your power cost is doubled by loss of efficiency. It can also mean that production suffers and length of campaign is reduced.

Kirk & Blum cooling systems have received wide acceptance in the glass industry because they produce money-saving results. Let our engineers—familiar with glass plant practice—advise you on your cooling problems. Contact us today. The Kirk & Blum Mfg. Co., 3104 Forrer Street, Cincinnati 9, Ohio.

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Vol. 42, No. 1 January 1961

THE GLASS INDUSTRY

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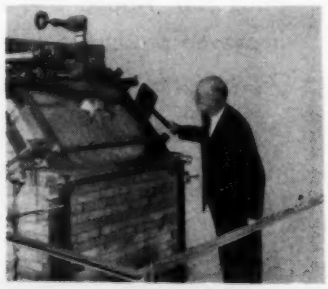

Oscar Burch (see page 13) is peering through a peephole in one of the Technical Center Furnaces which supplies glass for experimental machines.

New home for CORHART zircon refractories!

ONE OF the world's most advanced refractory manufacturing plants is under construction on a sprawling 30-acre site near Buckhannon, West Virginia.

It is the new 89,000 sq. ft. Corhart bonded zircon refractory plant, scheduled for completion early this spring. Corhart's wide range of slip cast and pressed zircon brick and shapes will be made here. The plant is a model of the continuing progress in refractory production made possible by Corhart's long-range research and development program.

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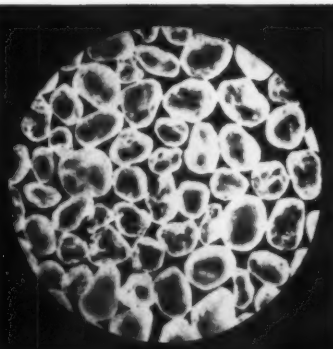

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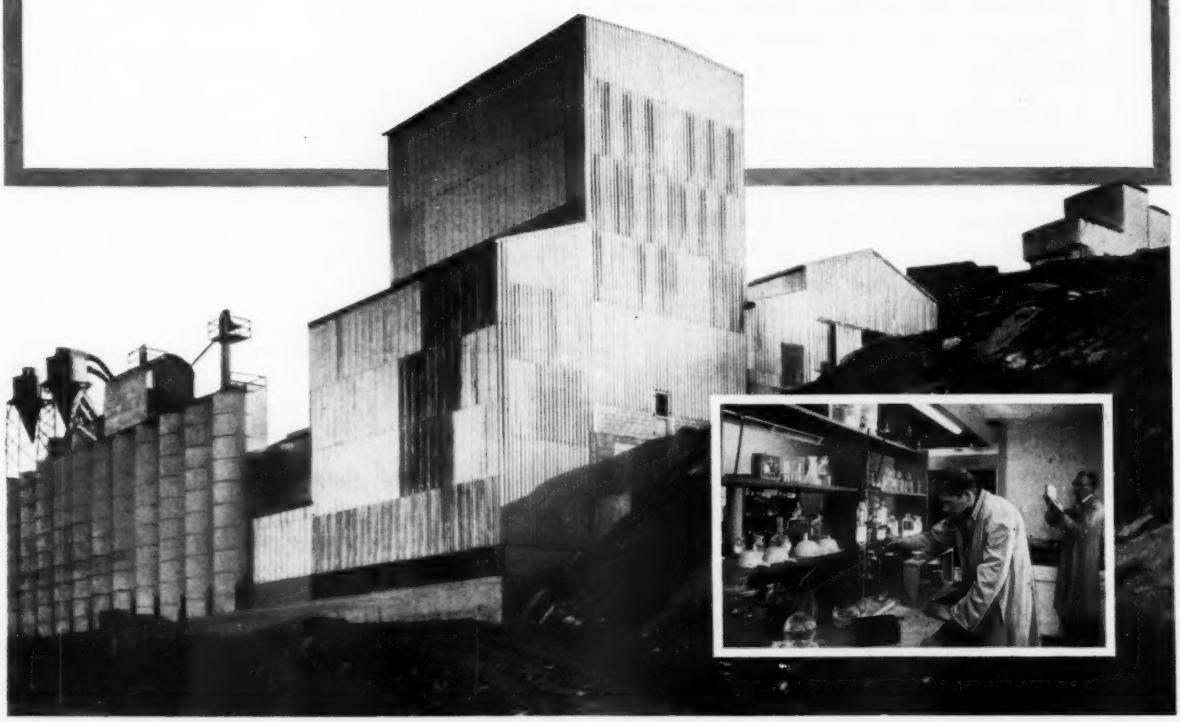

Interested in better Glass Decorating Colors?

New technical advances in glass decorating colors, both here and abroad, create new industry advantages . . . new industry opportunities. Translating these into practice is a function Ferro is uniquely fitted to perform. World-wide experience (through foreign subsidiaries), combined with new domestic facilities, bring glass decorators new know-how and colors possibly better suited to your application.

Things are happening in glass decorating colors. Let Ferro show you what they can mean to you.

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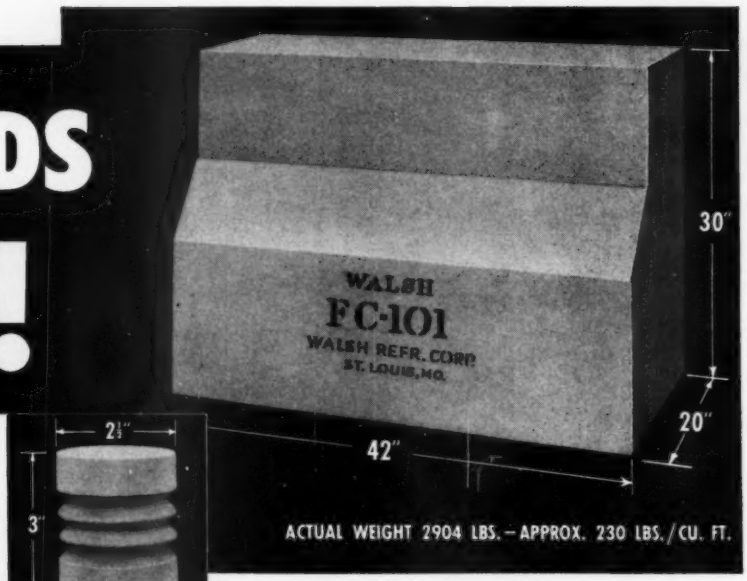
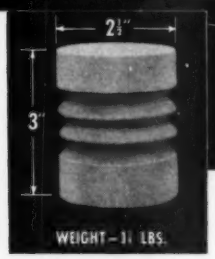
Color Division

Cleveland 5, Ohio • Pittsburgh 4, Pennsylvania

2 POUNDS OR . . . 2 TONS !





with FC-101, FUSION CAST REFRACTORY...

no shape too small . . . too large . . . too complicated

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Available in tilt cast or D. C. L. shapes, in sizes ranging up to 3,000 lbs. Match marking if requested.

Other WALSH Refractories for the Glass Industry

ZIRCON—analyses 99% pure zircon. Weighs approximately 220 lbs. per cu. ft. For use in bottoms of glass furnaces, as drip courses in silica crowns, burner blocks, port jambs, etc.

CAST MULLIFLUX B—Premium Quality Flux Block. Greater density, higher alumina content, more uniform expansion and superior resistance to higher temperatures and corrosion. Recommended for bottoms.

CAST FLUX—Slip Cast Flux Block. Machine ground on five faces and where necessary trued on all six faces for accuracy of dimension and ease of installation. For use under paving.

CSR—Cast Sillimanite Refractory. For safer, longer lasting protection in glass tank upper structures.

CSR FORTIFIED—Special Sillimanite Refractory. Unexcelled in upper structure "tough spots".

MULLITEX HB (High Burn) Super Duty Fire Brick. Noted for high modulus of rupture and cold crushing strength plus low porosity. Remarkable resistance to thermal shock. Withstands severe and punishing service.

MULLITEX, Super Duty Fire Brick. Excellent spalling resistance, lower porosity, good hot load bearing strength, and resistance to slag penetration.

Also, a complete line of Insulating Brick, Insulflux, glass tank insulating material, Silica Retort Patching Cement, High Alumina Refractories, Plastic Furnace Lining, High Temperature and Insulating Cements, Plastic Ramming Mixes, Wall Coatings and Refractory Castables.

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UNVARYING

COLOR

These colorful glasses and tumblers, products of Indiana Glass Company, Dunkirk, Indiana, can be productively loaded the full width of this Surface Combustion decorating lehr with no risk that the outside glassware will be over-fired. Radiant tube elements provide uniform distribution of heating clear across the belt. Naturally, this even temperature also prevents deformation.

Equally important, the radiant tube heating elements also produce an oxidizing atmosphere and keep impurities from contaminating the color.

If you seek close control of quality in the glass you make, at profitable production rates, see the people at Surface Combustion.

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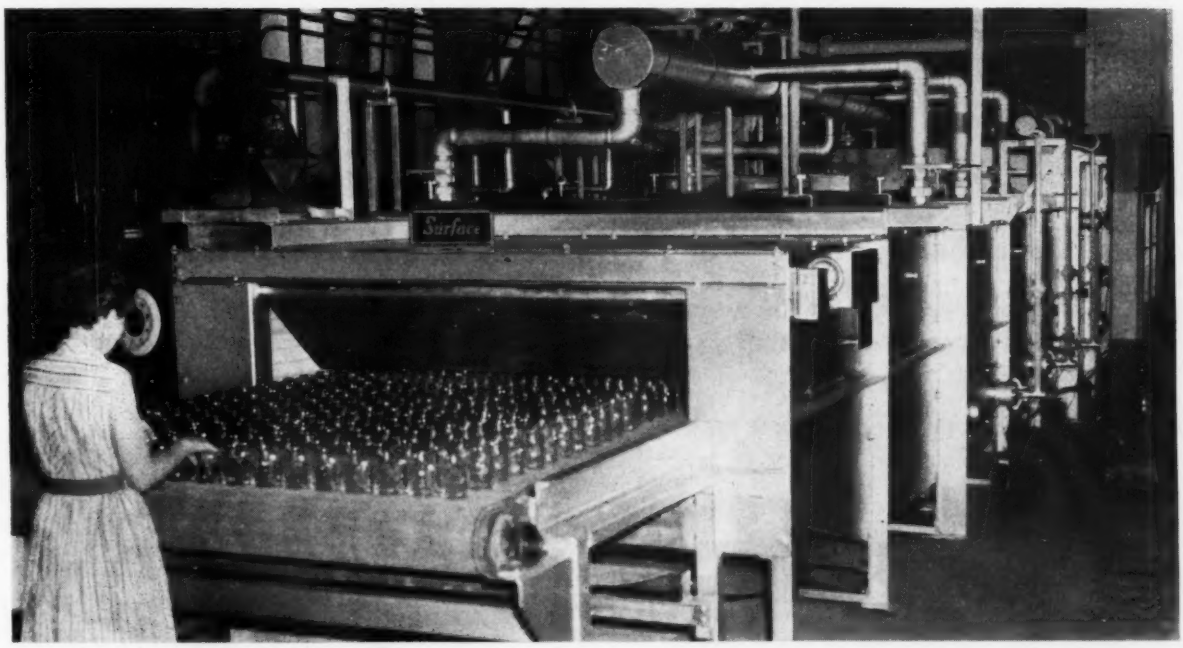
2378 Dorr Street, Toledo 1, Ohio

a Division of Midland-Ross Corporation



KAISER PERICLASE BRICK: STRONG BREATH OF LIFE IN A GRAVEYARD OF CHECKERS

Scene: inside a sodium silicate regenerator. Time: after a two-year campaign. At the center of the picture, a narrow test setting of Kaiser Refractories' Periclase checkers stands alone. Clean. Flues wide open.

In the foreground and background you can see an eroded jumble of competitive super-duty high burned brick that once stood just as high . . . now choking the life out of a campaign.

This test section just four flues deep set with Kaiser Periclase D unburned in the top five courses and Periclase A unburned below, proved to one furnace operator the superiority of these brick. And in many, many more installations, Kaiser Periclase brick are making glass furnace history—with campaigns up to five years, saving thousands of fuel dollars which repay added checker cost many times over.

For information about basic or fireclay refractories, contact your Kaiser Refractories Sales Engineer or write to Kaiser Refractories & Chemicals Division, Kaiser Aluminum & Chemical Sales, Inc., at any of the Division Offices listed below:

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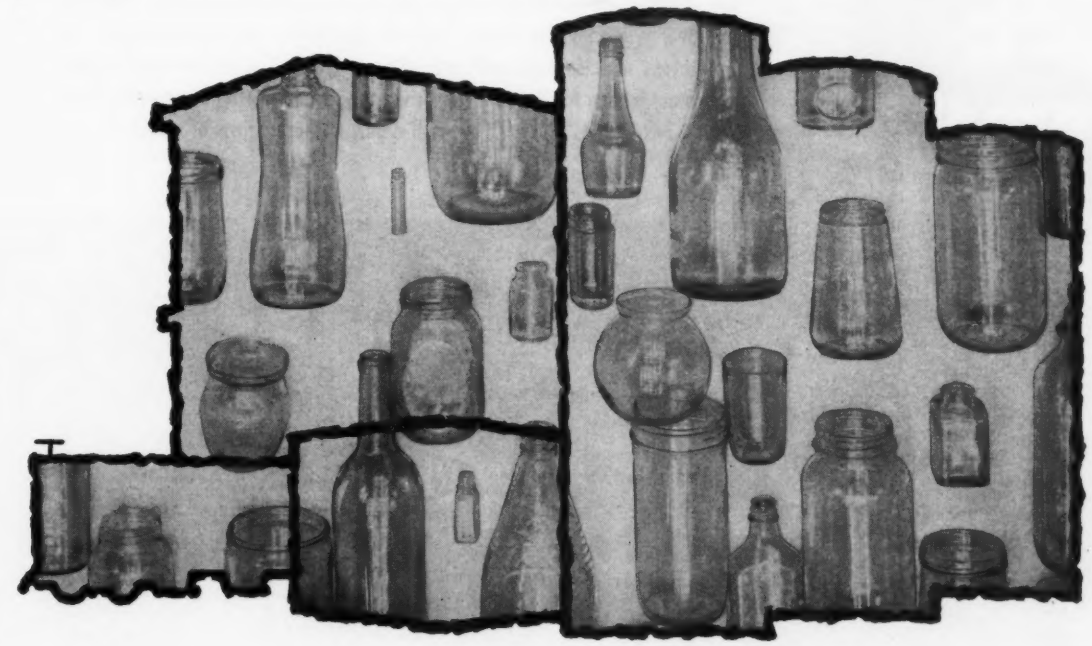
advance planning **OF EXPANDED SODA ASH PRODUCTION ANTICIPATES INDUSTRY'S GROWING NEEDS**



WEST END as the dependable soda ash source for the quality glass manufacturing industry in the West for 36 years is constantly enlarging its facilities to serve a growing national market efficiently and economically from multiple sources. Low cost production based on vast natural raw material supply is geared to meet all normal and emergency requirements of customers promptly, regardless of market conditions.

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WEST END CHEMICAL COMPANY • DIVISION OF STAUFFER CHEMICAL COMPANY

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New bottles for old wines

. . . are in many instances born here in the Overmyer Foundry. For efficient mould equipment has its beginnings in exactly the right iron. And . . . that's why Newton Davis, Overmyer Metallurgist, so often visits glass plants or welcomes glass men at Winchester, Indiana. What type of metal will do the job best? Is it the right iron to run hot? — or cold? Is it readily machinable? Will it withstand thermal shock? And resist growth and scale? These are a few of the many questions Metallurgist Davis answers. The Overmyer Foundry, modern in every operation, can produce ferrous and non-ferrous metals, steels and high alloy cast irons . . . and provide thorough laboratory testing for them by chemical analysis and photo micrography. Truly, Newt Davis and his foundry have had a part in the progress of glass!

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THE GLASS INDUSTRY
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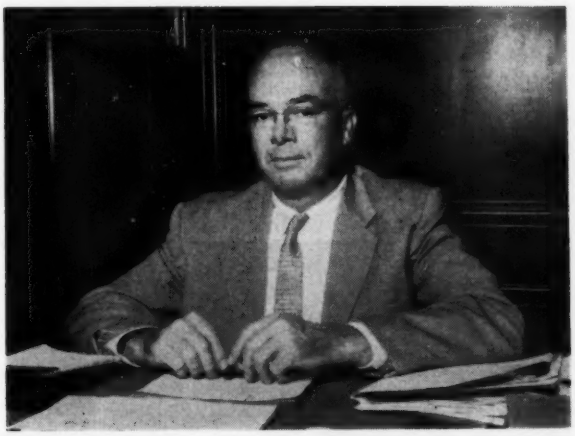
VOLUME 42 NUMBER 1 JANUARY 1961

OSCAR G. BURCH
1961 Toledo Award Winner



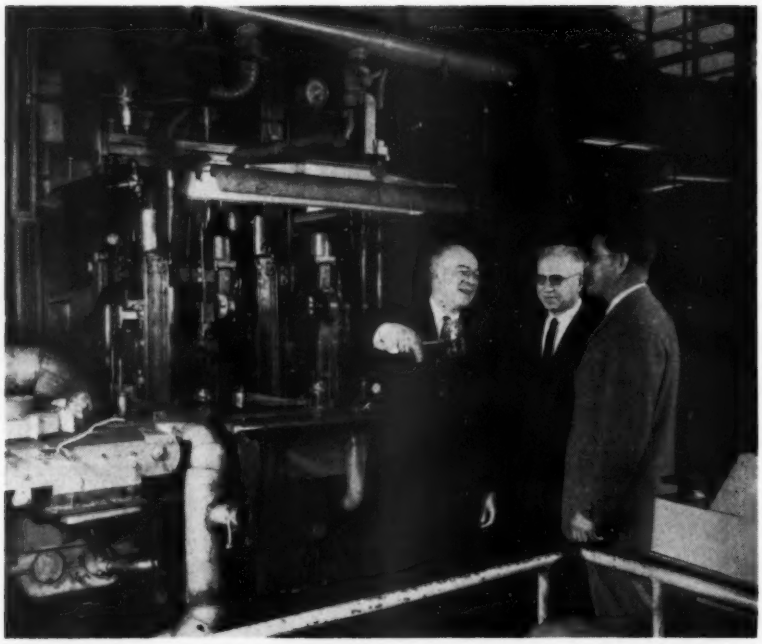
The 1961 Toledo Glass and Ceramic award will be presented to Oscar G. Burch, Vice President of Engineering and Research, Owens-Illinois Glass Company, on January 23rd at a dinner in the Commodore-Perry Hotel, Toledo, Ohio. This award is presented annually by the Northwestern Ohio section of the American Ceramic Society "to accord recognition for scientific or engineering achievement with broad interpretation."

HIS FIRST LOVE was medicine, and his early days at Washington University in St. Louis were spent in medical libraries and laboratories. But Oscar Burch soon realized he could not afford the cost of a medical education and so changed to engineering—a fortunate day for the glass industry.

Perhaps it was his early days in the laboratories as a medical student and later in chemical engineering that kept him from being desk bound. The fact that he now occupies a temporary office while the executive offices are being refurbished is not the reason you'll find him gone from his office. An office, whether large or small, is not of much significance to Oscar. He wants to be where the work is; hence, he spends much of his time at the Owens-Illinois Technical Center, some ten miles from his downtown office.

At the Technical Center, the heart of Owens-Illinois' research and development activities, Mr. Burch can see first hand the progress being made on plans he has put into action. Here he finds himself in the company of associates who speak his language—a language centered around not only the technological aspects of the glass industry, but also around plans for the future, and designs created to help carry out these plans at the Technical Center.

With the knowledge of how many changes have been made in the glass industry in his lifetime, Mr. Burch



Oscar Burch holds up an experimental right-weighted jar which has just been made on an IS machine in the Owens-Illinois Technical Center. This is one of the Center's research activities which seeks to further develop commercial machines in order to give an even better product. Joseph C. Hamilton, director of engineering (center), and James W. Hackett, director of research (right), are Mr. Burch's "strong right arms."

still feels glass has an unlimited and scarcely tapped potential. While he and his associates are working hard to dig deeper into the potential of glass, he feels they will still have a large number of research problems for generations to come.

The generations to come interest Mr. Burch from the standpoint of their ability to carry on with the work which has already been set into motion. He is an outspoken advocate of major changes in the teaching of ceramics in universities and technical schools. He believes many schools are teaching obsolete production methods that have not been used for years by manufacturers of glass, structural clay refractories and other ceramic materials. There must be, he says, up-to-date and even advanced methods taught for dealing with the present-day and future needs of the nation's multi-billion dollar ceramic industry.

The schools should concentrate, he feels, on teaching physics, chemistry and engineering subjects, as well as the properties of materials. The universities should teach students basic science and the physical and chemical properties of materials, and then let them learn modern production methods after graduation in the best possible place—the manufacturing plant.

When not in his office or at the Technical Center, Oscar relaxes in his home overlooking the picturesque Maumee River with his wife and two daughters. Frequently, though, even the family is forsaken for a little "home work" on technical projects, which he studies in his well-stocked library. However, he does put work aside for an evening of reading or an afternoon of golf—but those times are rare.

Mr. Burch received his Bachelor of Science Degree

(*Continued on page* 50)

Mr. and Mrs. Burch relaxing in the den of their new home. Very often he retires to this sanctuary by himself to devote more study to research assignments in glass.

CAMPAIGN To Spur Television Sales

"Operation Snowball" is the first attempt by a television component manufacturer to underwrite an extensive program designed to stimulate television sales. The purpose of the program is to show retailers and consumers the important product benefits contained in television sets. This can be accomplished only by the combined efforts of the industry.

WHEN the Psychological Corporation, a New York merchandising and motivational research organization, completed a recent survey for Corning Glass Works, it was brought out that many retailers and consumers of television receiving sets knew very little about the quality of the actual components within the respective sets.

Corning, with the cooperation of other interested manufacturers, will emphasize these consumer advantages in the new TV sets which have been made possible by recent technological advances in bulbs, tubes and other components. Called "Operation Snowball," the program will embrace all levels of set manufacturing and merchandising, from the components supplier to the retailer. The first phase begins this week at the International Home Furnishings Market (January 6-14) and is slated to extend through all of 1961.

According to John L. Hanigan, vice president and general manager of the Corning electrical products division, the company hopes the program "will generate momentum which will result in a multimillion dollar effort by the TV industry. Major set manufacturers and allied industries have indicated their support."

Basic objectives of the campaign have been set up by a five-man committee composed of Corning officials and members of the National Appliances and Radio-Television Dealers of America (NARDA). The objectives are to:

a. Expand the television market.

b. Encourage more trade-ins.

c. Stimulate demand for higher priced sets.

The sponsors of the promotion are planning national trade (dealer) and consumer advertising; local cooperative advertising; large-scale promotions at the dealer level, and an educational program directed at the consumer.

The following special activities and projects are scheduled for each month of this year.

1. "Information Please—Operation Snowball", a special exhibit and demonstration program in the Corning Glass Works offices, Merchandise Mart, Chicago, during International Home Furnishings Market ,Jan. 6-14.
2. Presentation of "Operation Snowball" program to January NARDA convention, Jan. 13-15, in Chicago.
3. A 30-day home appraisal and comparison trial of television receivers featuring the new 19 and 23-inch tubes. Results will be incorporated into a family benefit study.
4. "Operation Snowball" slide film program for use of manufacturers, distributors and dealers to acquaint their personnel with the industry-wide promotion.
5. "TV Trading Bee," a spring national promotion at the local dealer level, supported by extensive trade advertising; presentations to manufacturers, distributors, retailers. Supplemented by researched planbook, promotion and display material for dealers. City-wide promotions with advertising material supplied to newspapers, television, radio.
6. "1962 TV Demonstration Preview," a fall promotion at local dealer level to introduce new sets; supported by extensive advertising and promotional material.
7. Two-week city-wide promotions in cooperation with selected NARDA chapters. All local TV dealers will be included. Program designed to cover an entire market area.
8. Improved product benefit demonstrations in several of the nation's largest shopping centers. First program in March at the North Shore Shopping Center, Peabody, Mass.
9. A study on television retailing prepared in cooperation with the New York University School of Retailing. Scheduled for July.
10. A study of "trade-up" selling prepared in cooperation with the University of Pittsburgh School of Retailing. In September.
11. A case history manual, "The NARDA Method of Selling Television Sets." A review and projection of outstanding selling techniques. Presented to NARDA for servicing to NARDA members.
12. "TV Retailer of the Year" awards, honoring dealers making the most significant contributions to profitable selling through product benefit technique. Scheduled for 1962 International Home Furnishings Market.
13. Formation of a retail advisory group of selected dealers to develop new ideas for expanding the market.
14. Christmas campaign to encourage television gift buying. Program to emphasize advantages of having two or more TV sets in the home. Extensive consumer advertising.

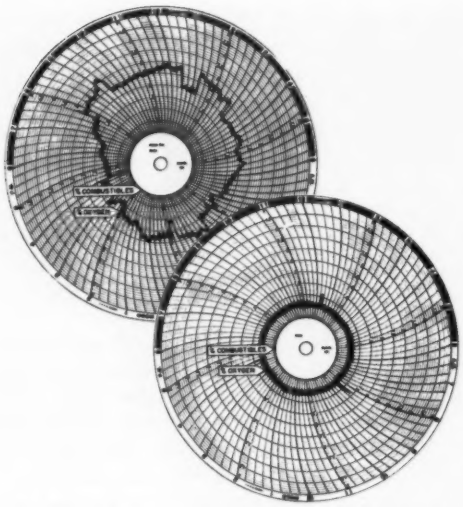


FIG. 1. Before-and-after oxygen and combustibles record. Direct-fired glass furnace.

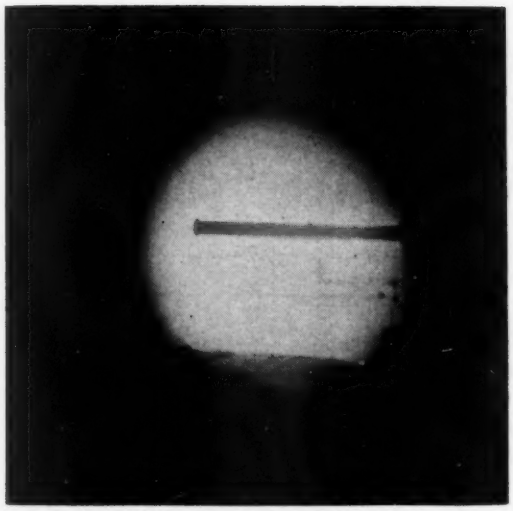


FIG. 2. Interior of furnace and water-cooled sample tube above molten glass.

Modern Glass Plant Instrumentation*

by R. K. Gunsaulus, Ceramics and Nonferrous Metals Division, Bailey Meter Company, Cleveland, Ohio

● WITH THE MODERN DAY REQUIREMENTS for improved equipment and plant efficiencies, better product quality, and better equipment life, instrumentation which is properly designed and applied can be a valuable tool in obtaining and maintaining these goals.

In this paper we wish to present some of the present modern day applications of metering and control equipment for the glass tank melting process.

Dual fuel firing of oil and natural gas has become a requirement on many new installations. Since the supply of natural gas can be curtailed because of seasonal gas requirements, methods have been made available to fire oil or gas fuels independently of each other or in any combination of both fuels.

The fuels are metered and controlled on the basis of their respective Btu capabilities so that operation can be carried on without upsets when transferring fuels, or when changing the relationship between two fuels fired simultaneously.

To accomplish this both fuels are metered and then totalized on an equivalent Btu basis. This totalized figure represents total Btu's, or total heats, supplied to the furnace. It is recorded for operator guidance and historical information, and also used as the control signal for controlling the fuel input.

Totalizing and controlling both fuels prevents overfueling. Since either fuel can usually supply melting requirements, double the amount of heat required could be supplied to the furnace if both fuels were fired simultaneously at a maximum rate. Control of both fuel valves from the total fuel signal prevents this from occurring since the total Btu input is maintained at the desired value. This desired value can be determined by the operator, or by automatic sensing and control. In either case, the Btu set-point signal which controls the total fuel is adjusted to meet the melting requirements.

Transfer from one fuel to the other requires only the establishment of the equivalent total Btu rate, as when firing the other fuel. In simultaneous fuel firing, changing the rate of one fuel with respect to the other is controlled on a Btu basis. Decreasing the one fuel is compensated by increasing the other fuel so that no net change in the heat input will result. These major changes are generally manual operations based upon the fuel availability, fuel cost, and other factors. Once set, however, both fuels can be automatically controlled together and in any percentage. One fuel can be base loaded (maintained at a set fixed rate) and the other fuel then becomes the automatically controlled fuel required for meeting the variable fuel demand of the process.

The combustion air flow is metered and is usually recorded on the same chart with the total fuel pen. This provides a good combustion guide and performance record of fuel-air ratio. The total fuel and combustion

*Presented at American Ceramic Society West Coast Meeting, October 15-17, 1959.

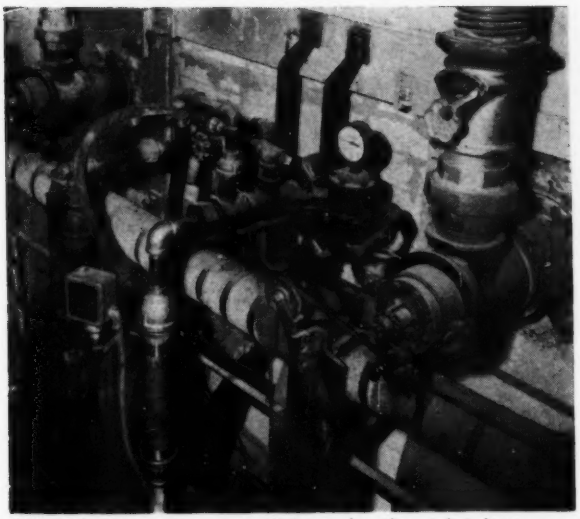


FIG. 3. Exterior view: water-cooled sample tube and inductor next to line of burners.

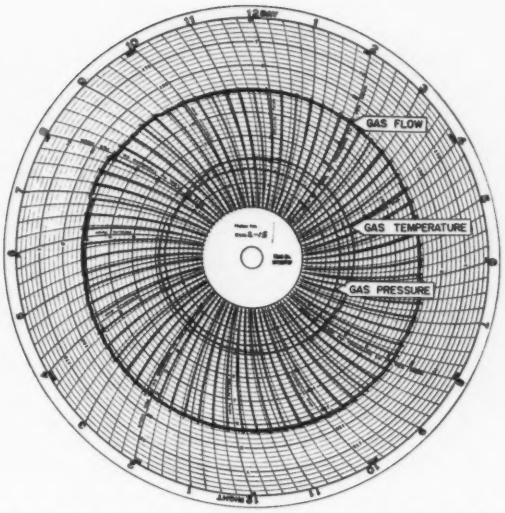


FIG. 4. Gas flow, gas pressure, and gas temperature record for side port furnace.

air measurements can also be used for automatic control of the fuel-air ratio.

Flow control of fuel to the furnace (either single fuel or dual fuel) has several advantages. By flow control we mean metering the fuel flow rate and then controlling this fuel rate constant. This desired rate can be manually set by the operator, or automatically set by tank temperature when a reliable temperature index has been established.

Since a glass tank has large thermal capacity, a change in fuel input rate is frequently not detected for some time. An undetected change in fuel flow can cause a major upset in melting conditions. Such changes in fuel flow can be caused by:

1. *Changes in fuel supply pressure as through changes in fuel system demand.*
2. *The interruption of fuel on adjacent furnaces during furnace reversals.*
3. *Changes in fuel oil viscosity.*
4. *Changes in temperature of the fuel supply.*
5. *Progressive plugging of the burners.*

The logical preventive action would be to maintain the flow constant at the desired set-point, thus avoiding upsetting changes in heat input. As an example of this variation, one glass tank installation being controlled from pressure in the fuel line to the burners, showed a change in the fuel flow rate for each alternate firing period. After reversal, the fuel flow would make an immediate drop from the flow rate that had existed at the end of the previous firing period. The flow rate would then gradually increase during the firing period. It was determined that when the gas was readmitted to these hot lines and burners, the gas increased in temperature and expanded. Since the gas pressure was being controlled constant, the gas control valve had to decrease the weight rate of gas in order to hold the gas pressure constant.

As the gas lines and burners cooled the automatic pressure control system increased the gas rate to hold the pressure constant. This operating pattern was reflected on the oxygen-combustibles recorder which monitored the products of combustion. Oxygen content of the flue gas increased immediately after reversal and then decreased gradually at the same rate as the fuel rate increased, thus showing that more actual flow was being added for the same amount of combustion air. Changing to constant fuel flow control eliminated this variation in both gas flow and gas analysis.

Automatic fuel flow control can also assist materially in balancing a multi-port installation. While changing a given burner, the total heat input to the furnace is maintained constant. In other words, a change in the rate of flow to one burner is offset in the other burners, resulting in no net change in net heat input. Without automatic fuel flow control, a change in adjustment of any burner will—in addition to changing the flow to that particular burner—make a change in the total heat supply to the entire furnace. This obviously makes burner adjustment quite cumbersome.

Where gas supply temperatures can vary significantly as a result of day-to-night temperature variations, volumetric gas flow measurement will be in error. Addition of automatic temperature compensation to the gas flow meter will provide weight measurement. If this weight measurement is then used as the signal for controlling the fuel valve, a constant weight rate of fuel will be supplied to the furnace. Any change in gas density, caused by temperature variation, will be automatically corrected. The result is a more stable furnace temperature. Because burner maintenance is more critical when firing oil, it is essential to detect changes in the flow distribution between burners as quickly as possible, as

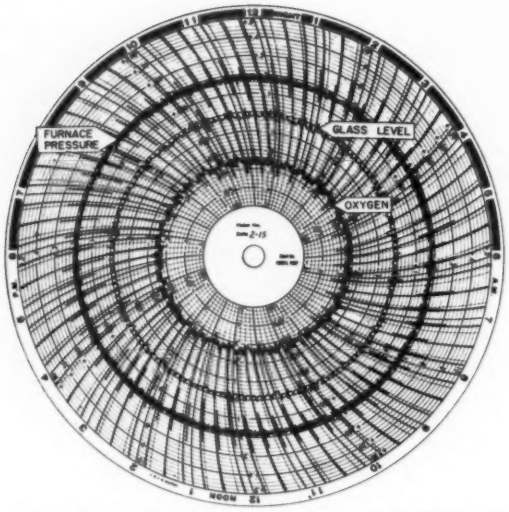


FIG. 5. Combining a maximum of records to obtain efficient use of panel space.

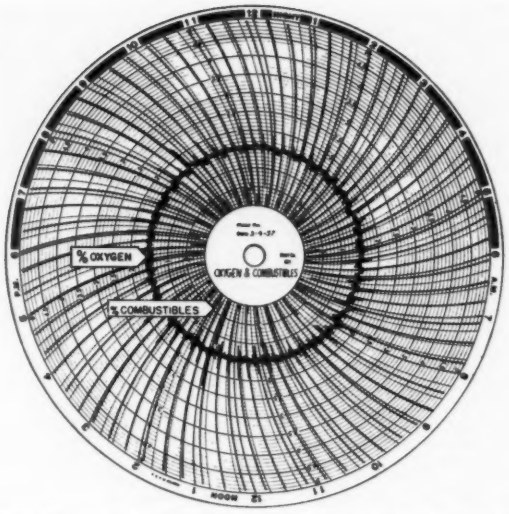


FIG. 6. Oxygen and combustibles recorded from end port regenerative furnace.

when any burner is plugging or becomes restricted. Oil header pressure is a good index to show burner condition since an increase in oil pressure will occur if the burners become restricted. An alarm can then alert the operator.

Within the last few years rapid advancement has been made in the application of the oxygen-combustibles recorder and controller to all types of glass tanks—end port, side port, and direct fired. It has contributed substantially to fuel savings and improved furnace performance. When properly applied it eliminates the deficiences of fuel-air ratio control. The metered combustion air is not the combustion air actually reaching the burners at the ports. Automatic control from gas analysis compensates for this deficiency, eliminating the effects of heat robbing infiltration. It also corrects for changes in combustion resulting in combustion air density variations due to atmosphere changes and changes due to fuel quality and fuel quantity. Dual fuel applications are quickly balanced for optimum combustion during firing or when transferring from one fuel to the other with the use of the combination oxygen and combustibles analyzer.

The sampling system must be able to handle the hot dirty gases and continuously deliver a clean sample to the analyzer in a minimum time. This is essential not only to maintain continuous, dependable results, but also for fast speed of response required for control of the combustion process. Sampling systems to meet these requirements are now available.

The combustibles measurement serves as a check on mixing efficiencies of the fuel being burned. It serves to check the oxygen measurement and in combination with the oxygen record supplies the complete story on the combustion process. Oxygen is the measurement of excess air; combustibles, the deficiency. Both oxygen and combustibles can occur at the same time and in varying amounts. Measuring both simultaneously aids materially in analyzing the combustion process for the three T's of combustion: temperature, turbulence, and time.

Maintaining a combustion-free atmosphere will, in addition to saving fuel, extend the life of the basic refractories used in the furnace and regenerators. Alternate reducing and oxidizing atmospheres, which cause volume changes and deterioration of the basic refractories should be eliminated.

One glass manufacturer uses the oxygen-combustibles relationship for maintaining the proper flame length. With the gas analysis made at the port outlet, an indication of combustibles shows that burning of the fuel is continuing past the port (the point of sampling) and even beyond. Changing the fuel-air ratio on that burner, until the combustibles just disappear, assures maximum flame coverage in the furnace without the possibility of a reducing atmosphere.

With the increased use and interest in recuperators on direct-fired furnaces, such as used in some fiber glass operations, the gas analyzer can be of material benefit. Very close combustion control is required to maintain peak temperature in the melting process, and control from gas analysis is the best method for controlling the nozzle mix type of burner used with the preheated combustion air application.

The portable, intermittent oxygen and combustibles indicator-analyzer complements the continuous recorder-controller in helping to maintain proper adjustment of individual burners. The continuous analyzer is used for the day-to-day, year-in, year-out operation for operator guidance, historical recording, and controlling. It usually employs a single point of sampling on each side of the regenerator furnace. To assure that this point represents

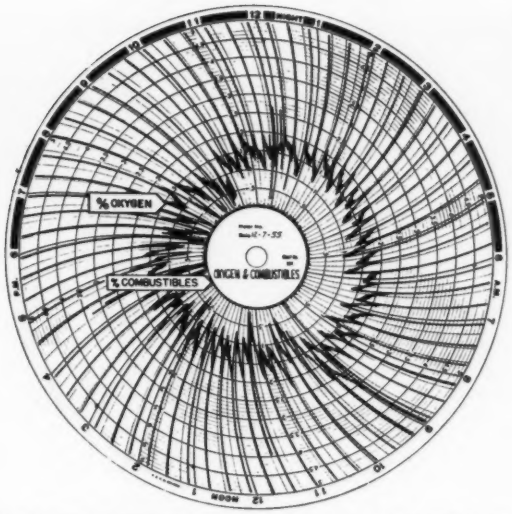


FIG. 7. Record from same furnace as Fig. 6. Combustion air is controlled from oxygen analysis.

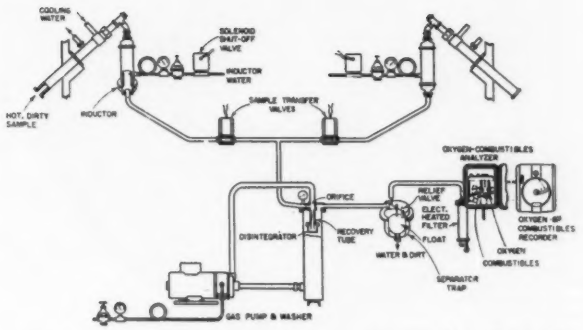


FIG. 8. Gas sampling system used for oxygen control in Figs. 6, 7, regenerative type furnace.

over-all tank combustion, periodic checking of all burners is necessary to maintain balanced firing conditions. The portable analyzer is designed for short periods and intermittent use and provides the necessary tool for checking burner and port balance. Both the continuous and portable analyzer are needed and serve as a team to maintain the combustion process at its peak efficiency.

Proper furnace pressure measurement and control is also important in the operation of the furnace. Too low a pressure causes cold air infiltration, and too high a pressure forces hot gases out through the brickwork. Maintaining a constant furnace pressure eliminates the variables associated with changes in pressure which change heat input and heat loss. Measurement of the pressure on each side of a regenerative type furnace to obtain an average, is generally considered good practice. This average pressure is then compared to an atmosphere measurement taken adjacent to the tank connection so as to compensate for atmospheric variations. The differential between furnace pressure and atmosphere is the impulse sent to the furnace pressure instrument which records and controls this function.

Furnace pressure is also important to maintaining consistent flame position within the tank, and maintaining proper excess air. Variable pressure means variable air infiltration and air leakage, resulting in changed combustion air.

A new approach to the problem of complete automatic tank control has resulted in the successful application of tank temperature control to a regenerative type furnace. Automatic control of a direct-fired furnace is not uncommon in the industry. However, application of similar control equipment to a furnace which is reversed has, heretofore, not been successful, unbalances, which can occur through furnace reversing, and the large heat storage of the tank have made automatic control impractical.

A new type of control has been developed which integrates the deviation of tank temperature from set-point temperature with respect to time. This generates a control signal which is used to change the fuel and combustion air. This signal is stored and a step change is made in the furnace firing rate at definite time intervals, much as an operator does in tending the furnace manually. Or the signal can be used to control continuously from integrated temperature. Either method can produce stable tank temperature automatically.

An installation of this integrated temperature control has been in successful operation for over a year. Fuel savings are running one per cent to two per cent. Furnace temperature is stable. The complete results of this close furnace temperature control have so far not been evaluated. Its chief advantage is its aid to the primary purpose of the melting furnace; namely, to produce quality glass at the desired tonnage rate. Being difficult to evaluate, the total dollar advantage has not been determined. However, all of the results of this closer temperature control are in the definite direction of maintaining better glass quality, improved furnace refractory life, and better overall tank operation. With the other furnace instrumentation and proper design of the furnace and overall plant, automatic temperature control will help to reduce the manpower required for operation.

Automatic furnace reversal can assist in saving manpower and Btu's and maintain more stable furnace conditions. Having an automatic system to reverse the furnace can ovbiously release, for other duties, the operator who formerly reversed the furnace by hand. He can then use this time for closer supervision of other factors in the process under his care and responsibility, resulting in a saving, or more efficient use of manpower.

When the furnace is reversed under optimum con-

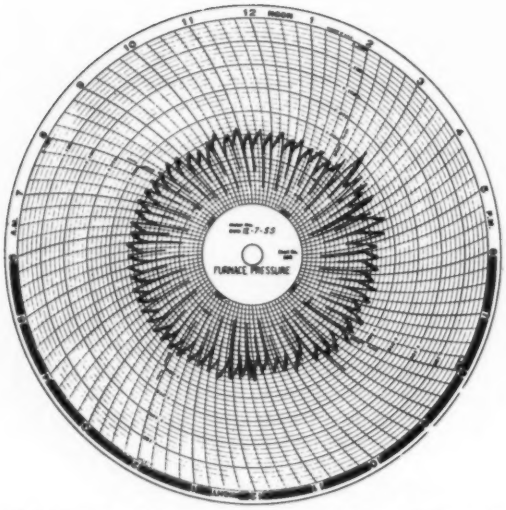


FIG. 9. Chart record from another furnace; furnace pressure is on manual control.

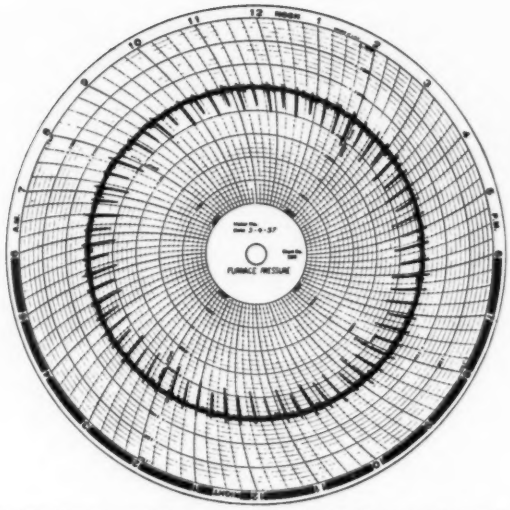


FIG. 10. Chart record from furnace in Fig. 9; furnace pressure is on automatic control.

ditions through the use of an automatic reversal system, the time between fire off and fire on will be reduced as compared to manual reversal. Heat is lost during reversal and less heat loss will occur with more efficient reversal, resulting in more stable furnace conditions and savings in fuel.

An automatic reversal system will also enable the operating engineer to determine the optimum length of the firing period for his particular furnace. Investigative work indicates that shorter firing periods are advantageous from the standpoint of holding closer furnace temperature. Furnace temperature stability is the primary improvement, as tests have shown no significant change in fuel efficiency for different firing times. An automatic furnace reversal system is a combination of timers and relays designed to perform specific functions in a specific sequence or time. The flow of air and flue gases through the system must be reversed after the fuel is shut-off. The flues and checkers must be purged of waste gases so that the proper supply of air is available when re-establishing the fire. Interlocks and alarms, and their suitable tie-in with the controls, must be provided to assure a stable and reliable system for reversing the furnace.

Automatic reversal of the furnace is usually performed on the basis of time. A suitable timer handling both sides, or individual timers for each side (if the firing periods are to be different) is required. Operation of the reversal system can also be initiated by manual pushbutton. High checker temperature can also initiate the reversal in event of high checker temperature.

Remote manual operation is usually provided. Signal lights show the positions of valves, dampers, etc. These are helpful in the isolation of trouble, and show the operator the position of each item during operation. Local reversal of each item is also provided in the event of a reversal power failure. Sometimes manual by-passes are built into the piping to permit servicing control valves without shutting down the process.

The reversal system should be interlocked to prevent the incorrect positioning of a damper or a valve before reversal can progress or fuel be readmitted. Alarms to back up the timers are essential in case of failure to start reversal, or to complete reversal, or in the event of high checker temperatures.

There must be a definite coordination of the reversal system and the furnace controls for a satisfactory reversal system and stability of controls. Various functions in the control system must be locked and unlocked in the proper sequence to assure stable return of the firing conditions. The proper purging of the furnace in a minimum of time must be accomplished by tie-ins with the furnace combustion air damper and stack damper used to control the fuel-air ratio and furnace pressure. Fuel return at a controlled rate to prevent furnace flooding and over-fueling is another important requirement. All these interconnected factors require careful attention in the design of furnace controls and reversal system.

One of the best ways to determine the minimum fire-off time is with the combustibles flue gas analyzer. The purging is decreased until combustibles just begin to show up following fuel readmission. This shows that insufficient oxygen is available to burn all of the fuel. Increasing the purge time gradually until no combustibles are present gives the optimum setting. The combustibles record of the continuous gas analyzer also serves as a continuous monitor to check each reversal to assure that conditions remain the same as at the time of initial adjustments.

A relatively new method of glass level measurement is now commercially available utilizing the new, modern techniques of nuclear radiation. The principle was first

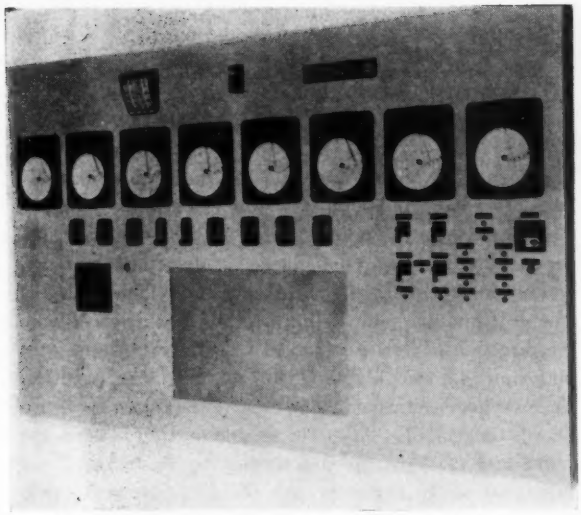


FIG. 11a. Modern glass tank control center with complete centralized control information (see text).

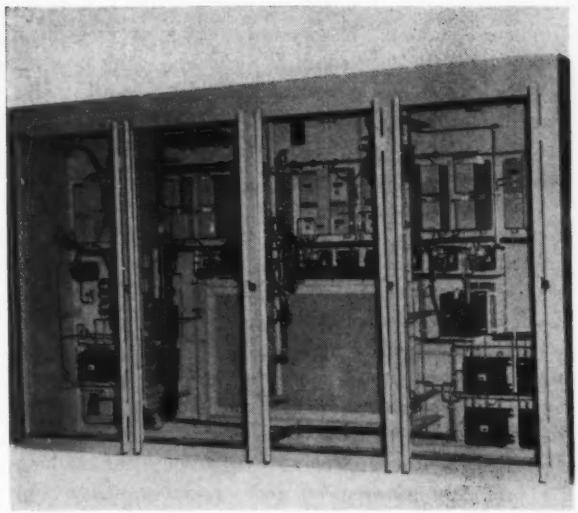


FIG. 11b. Rear view of glass tank control center shown in Fig. 11a.

adapted to glass tank level measurement in England, but several installations are now in operation in this country.

A nuclear source in a lead shielded holder is mounted on one side of the glass forehearth at the metal line. A detector sensitive to gamma radiation is mounted directly opposite the source on the other side of the forehearth channel. The quantity of gamma rays received by the detector is a function of the distance between the source and detector and the density of the intervening material. The glass level is measured as a density change in terms of glass level variation. The distance factor is constant since the source and detector units are at fixed positions. This method has the obvious advantages of no moving parts, no probe, and no parts in contact with the glass or furnace atmosphere.

Because of the high density of the glass and the furnace brick, the fact that the radiation received by the detector varies inversely as the square of the distance, measurement of glass level is restricted to definite distance limits. A distance of 3 to 5 ft. between the source and the detector is acceptable without exceeding the practical radioactive source sizes. When using this method glass level is generally measured in the forehearth.

Calibration of this level gage is made at the time of installation. This is accomplished by adjusting the source with the glass at the desired level. A standard reference gage such as a dip-stick, or "hockey-stick", is used for this purpose, and to make periodic calibration checks to correct for slight changes due to refractory erosion at the metal line, and source decay. The radiation source usually used is cesium-137, which has a half-life of 33 years, so calibration change from source decay is negligible.

Safety precautions determined by the AEC assure safe handling of the radioactive material. The source is contained in a lead shielded container designed to be better than the maximum safety requirements for this type of radioactive source. A shutter permits closing the radiation aperture for complete isolation and storage.

An electronic recorder is used to record the glass level from an amplified signal from the radiation detector. This signal is directly related to the glass level. Conventional control of the batch charger by either on-off, or modulating control can be utilized from this measurement.

Mention should also be made of some of the newer concepts of computers and data logging equipment as applied in a glass plant. New techniques in electronic instruments have made available fast data logging and scanning. A large number of points can be scanned at any desired speed and logged for operational, historical, or accounting purposes.

Off-standard factors can be alarmed, and logged separately to provide continuous information on trouble points. Corrective measures can then be taken to prevent damage to equipment and loss of product quality.

This type of system can monitor all of the important measurements in the plant thereby permitting close coordination of all measurements and automatic controls at one or more centralized control centers.

Computers or performance monitors capable of making calculations and displaying this information for operational, historical, or accounting purposes are also tools to be considered.

For example, one possibility is computing the per cent pack and defects in the forming operation of glass containers. Measurement can be made of the machine sheer cuts and total ware packed and the per cent pack computed. This, together with the number and type of defects, presented on an hourly-or half-hour basis, to the forming operator, will enable closer control of the

forming operation. It will also release the personnel which formerly checked these facts and computed the per cent pack for other quality control work. This should improve the overall quality, and the increase in percent pack may justify the added equipment over an acceptable payout period.

Computers can, of course, be made to do many more things, sometimes at a large capital investment. Justification has to be made for the benefits received as against the capital expenditure, to warrant their use or consideration. Undoubtedly, plants of the future will probably make increasing use of data loggers, scanners, performance monitors, and computers. It is, however, necessary to be able to control and measure each function separately before the units can be put together in a complete automatic plant. Techniques for making the primary measurement and providing stable and dependable control must be proven first, as the centralized control can be no better than the information it receives.

The illustrations in this article are examples of some actual operating installations.

In the before-and-after oxygen and combustibles record (Fig. 1) on a direct-fired glass furnace, the products of combustion are sampled and recorded from the refining section of the melting chamber. The left chart shows the typical variations that existed during manual operation; the right one, the automatic operation while firing #6 fuel oil. Continuous automatic operation has resulted in a higher permissible furnace pull, less seeds in the finished ware, better fuel economy, minimum deterioration of refractories and superstructure, reduction of blister tendencies, better control of glass color, and proper flame pattern.

The interior of the furnace and the water-cooled sample tube above the molten glass is illustrated in Fig. 2.

An exterior view in Fig. 3 shows the water-cooled sample tube and inductor adjacent to the line of burners.

Gas flow, gas pressure, and gas temperature (Fig. 4) are recorded for a side port furnace having a designed melting capacity of 200 tons per day. The fuel gas flow meter is automatically compensated for gas temperature variations and is then used to control the flow of fuel to the furnace.

Figure 5 illustrates the versatility of combining a maximum of records in one recorder to obtain efficient use of panel space. This chart from the same furnace shows the oxygen, glass level, and furnace pressure records. Each is also controlled. Glass level is controlled by on-off action of the batch feeders.

The chart in Fig. 6 is from an end port regenerative furnace; oxygen and combustibles are recorded. Combustion air was being supplied manually.

Figure 7 is from the same furnace. Now combustion air is controlled from oxygen analysis. Note that the combustibles are showing up at each alternate furnace reversal indicating insufficient purging time, which was later corrected by adjustment of the purge time in the reversal system.

Figure 8 shows the sampling system used for the oxygen control shown in Fig. 7. The hot, dirty gas sample enters through the water-cooled sample tube. Water sprayed tangentially into the inductor thoroughly submerges the gas sample in water, cools the sample, and keeps the sample lines from plugging by dust and dirt. In the gas pump and washer, water from the pump jets through an orifice. The resulting vacuum pulls the sample from the sample line. In the disintegrator cup the direction of flow is reversed twice to mix the sample and water thoroughly, and to wet the dust particles. The sample—entrained water—dirt mixture is introduced tangentially into the separator trap where the water and dirt mixture are thrown to the outside and then goes to the drain through the float operated valve. The clean, cool gases leave at the top of the separator and go to the heated filter assembly. The heated filter assembly assures a clean, moisture-free sample to the analyzer. The gases are analyzed by the catalytic combustion principle, and the percents by volume of oxygen and combustibles are recorded on the same two-pen recorder chart.

Figure 9 is a chart record from another furnace, and the furnace pressure is on manual control. Note that for either side firing, the furnace pressure increases as the firing period progresses. This installation is equipped with a mechanically induced draft fan which handles a constant volume of gas. As the temperature of the waste gas increases with the continuing firing, the gas volume increases. As the gas volume increases, the constant volume fan pulls a decreasing weight of gas, and this results in a gradually increasing furnace pressure.

The chart in Fig. 10 is from the same furnace referred to in Fig. 9. It shows the resulting furnace pressure on automatic control.

The modern glass tank control center (Fig. 11) provides complete centralized control information for the operator, as well as remote manual operation of all functions and historical trends on the recorders. The first recorder on the left records glass level and provides glass level control. The next one records four crown temperatures. The third records fuel oil flow, temperature, and pressure and integrates (totalizes) flow. The fourth records the same information for natural gas fuel; the fifth, records oxygen, combustibles, and furnace pressure and it also controls the oxygen; the sixth records right and left flue and stack temperatures; the seventh records the right checker temperature and right atomizing air pressure; and the last one records left checker temperature and left atomizing air pressure.

Immediately below the seventh and eighth recorders is the automatic furnace reversal system. Hand-automatic control stations reading from left to right provide control of the batch chargers, oil temperature, oil flow,

(*Continued on page* 48)

Conditions of Glass Formation Among Simple Compounds

IN FOUR PARTS, PART III (Continued)

by W. A. Weyl and E. C. Marboe

College of Mineral Industries, The Pennsylvania State University, University Park, Pennsylvania

4. Kinetic Aspects of Incompatibility

The strict coordination requirements of Si^{4+} ions (tetrahedral) and Mg^{2+} ions (octahedral) are easily met in a forsterite crystal, $2MgO.SiO_2$. The melting point of this compound (1890°C) reveals that the forsterite retains its long range order up to very high temperatures. If long range order would be the only difference which exists between a crystal and a glass as a supercooled liquid one should think it possible to build up non-periodic structures in which SiO_4 tetrahedra and MgO_6 octahedra are interlinked in non-stoichiometric ratios. However, the lattice of a liquid has to meet the coordination requirements of its cations in a way which meets certain dynamic conditions.

A non-periodic structure of a mixture of two incompatible compounds can be obtained experimentally by the simultaneous condensation of the vapors of the two compounds. The resulting solid is amorphous, its structure according to our classification[12] is "chaotic" and corresponds to that of a metamict mineral. Such a non-periodic solid is not a glass; it will not gradually soften on heating and it can not flow.

In order to be a glass a solid has to meet certain dynamic conditions when its temperature is raised. Because of the importance of these dynamic or kinetic aspects we emphasize the role which the polarizability of all ions plays in the achievement of compatibility.

The polarizability of an ion can but must not necessarily affect structural relations. As far as crystal structures are concerned the volume relations are by far the most important ones. The same applies also to those phenomena in which the atoms within a solid vibrate around their equilibrium positions. The low temperature thermal expansion of a sodium-strontium silicate glass, for example, is not noticeably changed if the Sr^{2+} ions are partly or fully replaced by the much more polarizable Pb^{2+} ions. Both cations have the same size and charge and are likely to occupy similar positions in these glasses. In contrast to the low temperature thermal expansion which does not involve any place changes, the viscosities of the two glasses are very different. The lower softening temperature of the lead glass reveals that the polarizability has become an important factor because viscosity is a property which involves flow of ions past one another. For this reason the polarizability of all ions is important. The structure of a molten silicate requires a geometry which not only meets the screening demands of the cations but one which also permits certain place changes and consequently the compatibility depends upon the polarizabilities of all ions which are involved.

Constituents which have high polarizabilities, e.g., cations of the non-noble gas-type and large anions such as S^{2-} ions, are conducive to the formation of defective structures. The accumulation of defects is another factor which affects the kinetic function of a structure and the way it forms.

(a) Forms of Precipitation

Our previous discussion of incompatibility due to the formation of volatile compounds (II 3) impressed upon us the importance of the kinetic aspects. The concepts of compatibility and incompatibility with respect to the formation of a homogeneous liquid which can be supercooled to a glass have kinetic aspects which decide the form in which a solid is precipitated on cooling or reheating. Our knowledge of the equilibria which is vested in the phase diagram of the system tells us that a system at a given temperature has reached its stable condition if it consists of a liquid phase, let us say 95 per cent of a liquid, and of a crystalline solid, e.g., 5 per cent silica or titania. The diagram cannot tell us that for a given rate of cooling the one system produces a glass which contains a few large crystals of tridymite or cristobalite and the other an opaque enamel which contains a very large number of microscopic crystals of rutile. This kind of information cannot be expected from phase diagrams because it refers to the kinetic aspects of incompatibility and therefore it cannot be expected from an equilibrium diagram.

The equilibrium aspect tells us that we cannot produce a silicate glass which contains a substantial amount of either fluorine or chlorine. The kinetic aspects of the system, however, reveal that the kinetics of the formation of volatile SiF_4 is sufficiently slow to make it possible to manufacture fluorine-containing silicate glasses in spite

[12]Mineral Industries Contribution No. 59-95

of the unfavorable equilibrium conditions. The kinetic aspects of making a corresponding chloride glass are not as favorable and hence no substantial quantities of Cl^- ions can be retained in a soda lime silicate glass.

The same situation applies to the interaction of glasses with refractory materials. The compatibility of mullite with a soda lime silicate glass does not exclude it from being a useful refractory material. The favorable kinetic aspects outweigh the unfavorable equilibrium conditions. For these reasons it becomes important for a glass technologist to learn to understand rate phenomena. The rates of nucleation and of crystal growth determine the form in which a solid will precipitate from a glass on cooling or reheating.

Let us briefly discuss some examples which are of interest to the glass technologist. Metallic gold dissolves in a glass melt primarily in the form of a metal vapor which consists of gold atoms distributed in the molten glass. As the temperature is lowered the gold becomes incompatible and precipitates in the form of numerous submicroscopic nuclei. The precipitation of gold or of NaF, CdS, or TiO_2 from a glass on cooling or reheating looks distinctly different from the precipitation of similar quantities of silica, wollastonite, or devitrite, the common products of devitrification of a soda lime silicate glass. The quantities of the solid phase precipitated may be the same but silica appears in the glass as a "stone" and wollastonite may form large spherulites. The forms of precipitation are the result of the kinetic aspects of incompatibility, namely, the rates of nucleation and of crystal growth. The effect which time and temperature have on the processes of crystallization and nucleation of simple compounds have been clarified primarily by G. Tammann[24] and his school. Whereas Tammann's work was done mostly with organic substances, H. H. Blau[25] pioneered in applying these principles to the manufacture of fluoride glasses with controlled opacity.

P. P. von Weimarn[26] studied the forms of precipitation from aqueous solutions and he derived his "Laws of Precipitation" by introducing the "condensation pressure," the "condensation resistance," and the "specific supersaturation." Following the change of these parameters with time during the precipitation he was able to interpret and predict the change of effects of temperature, concentration, and solubility upon the crystal size of a precipitate.

Precipitations such as occur in colloidal gold sols as the result of collisions of particles have been treated mathematically ever since M. von Smoluchowski[27] derived his formulas which connect the concentration and the radius of attraction of the particles with their rate of coagulation. The classical approaches to crystallization and nucleation by P. P. von Weimarn, G. Tammann, and M. von Smoluchowski have their modern counterparts but all these theories have one serious shortcoming.

In spite of all these diversified efforts and achievements one of the fundamental questions concerning the forms of precipitation had to remain unanswered, namely, how the nature of the precipitating phase affects its nucleation and crystallization rates. The observation that from a certain glass on cooling at a certain rate a certain quantity of SiO_2 or TiO_2 crystallizes out can easily be understood. The problem is to account for the fact that SiO_2 precipitates as a "stone" but TiO_2 as an opacifying phase which consists of an extremely large number of microscopic crystals.

In dealing with this problem we can be more specific and ask why is the formation of a nucleus of tridymite such a rare event that the total precipitation occurs in the form of a very few crystals, whereas the nucleation of titania, gold, and cadmium sulfide is so frequent that many nuclei form and none of them have a chance to grow to a large size?

The conventional approach to this problem is based on the change of solubility or compatibility with the temperature using the precipitation laws of von Weimarn as a guide. If we derive the solubility of gold in a soda lime glass from its vapor pressure we find that there is a sharp drop of solubility on cooling. The same relation might apply to the solubility and the precipitation of copper in a copper ruby glass. In both cases the precipitates are metals which are foreign to the structures of the glasses and have solubilities which are less than 1 per cent. The factors which influence the compatibility of gold and copper with different glasses and the forms of precipitation have been discussed by W. A. Weyl.[28]

The widely different forms of precipitation of silica, silicates, the fluorides of sodium and calcium, the sulfide and the sulfoselenide of cadmium, apatite in opal glasses, and titania in enamels cannot be attributed to widely different solubilities but must be the result of structural differences which affect the rates of nucleation.

The rate of nucleation is a function of the absolute temperature and of the height of the energy barrier which a system has to overcome in order to form a nucleus and both parameters depend upon the nature and the structure of the precipitate. The high rate of nucleation of apatite is used for opacifying borosilicate glasses. Apatite in such a glass forms at high temperatures and nucleation processes (crystals, liquids, or gases) which occur at high temperature have high rates because of the high kinetic energies which are available for overcoming the energy barrier of nucleation.

Crystals which have defective structures cannot be overheated but change abruptly into a fluid melt. Melts of this type, e.g., fused V_2O_5, cannot be strongly supercooled but nucleate and crystallize readily on cooling. The drastic difference which exists in the forms of precipitation between devitrification or stones on one side and opacity on the other is not always a function of the absolute temperature but also depends upon the ease of nucleation of defective structures as compared with the high energy barrier which opposes the formation of "perfect crystals."

(b) Nucleation of Fluorides

An oxide mixture which corresponds to the quaternary eutectic MgO-CaO-Al_2O_3-SiO_2 can form a glass in which 2 per cent of the CaO can be replaced by the Na_2O without interfering with glass formation. Neither does the substitution of 2% CaF_2 for 2% CaO interfere with the homogeneity of the glass. However, if both substitutions are carried out simultaneously of if 2 per cent of NaF are added to the eutectic composition, NaF crystals will precipitate from the glass. The competition of the Ca^{2+}, Mg^{2+}, Al^{3+}, and Si^{4+} ions with their stronger electrical fields for the doubly charged more polarizable and better screening O^{2-} ions leaves, so to speak, the poorest screeners, the F^- ions, for the least demanding of all cations, the Na^+ ions. Such a glass is very sensitive to alkali fluorides. This glass will not permit the growth of a few large NaF crystals but it becomes opaque due to the precipitation of many small crystals. The low rate of growth of these NaF crystals can partly be attributed to the fact that the growth of such a crystal draws F^- ions from the glass around the nucleus. This change in composition raises the viscosity of the glass surrounding the crystal and slows down its further growth. The same would apply to the precipitation of CaF_2 which occurs in some opal glasses.

The reason for the precipitation of NaF should not be sought in any particular chemical affinity between sodium and fluorine but it is rather the result of the poor screening power of the F^- ions as compared with that of O^{2-} ions. During the reshuffling of ions the Mg^{2+}, Ca^{2+}, Al^{3+}, and Si^{4+} ions exert stronger electrostatic attractive forces upon O^{2-} ions than upon F^- ions.

Some opal glasses which have a high lime content precipitate CaF_2 in addition to NaF.

Both crystals NaF and CaF_2 under the conditions at which they form are likely to have a number of defects due to the presence of "foreign atoms" in their lattices. The NaF crystals are likely to contain some CaF_2 and CaF_2 crystals are likely to contain some NaF. These "impurities" may not be significant from an analytical point of view but they are conducive to nucleation through the formation of vacant lattice sites, e.g.,

$$Na^+_{1-2x}\,Ca_x^{2+}\,(\text{Cat. Vac.})_x\,F^-$$

and

$$Ca_{1-x}^{2+}\,Na_x^{+}\,(\text{An. Vac.})_x\,F^-_{2-x}$$

The NaF crystals contain one vacant cation site for each Ca^{2+} ion which replaces two Na^+ ions. The CaF_2 crystals on the other hand develop anion vacancies because a Na^+ ion which occupies the place of a Ca^{2+} ion introduces a deficiency of positive charges and the lattice responds to this deficiency by leaving some anion sites vacant.

Anion vacancies as well as cation vacancies lead to a disproportioning of the binding forces which is conducive to nucleation. Hence we may expect that the NaF crystals which form in an opal glass have a higher concentration of defects than the pure crystals and in every case nucleation of alkali halides is "defect controlled".

(c) Nucleation of Sulfides

A group of colored glasses ranging from yellow to red is based on the formation of submicroscopic crystals of the sulfide and sulfoselenides of cadmium. When sulfides are introduced into a glass, the S^{2-} ions can be pictured as being statistically distributed within the anionic network at high temperatures. The S^{2-} ions have the same charge as the O^{2-} ions but due to their larger sizes they are more polarizable, which means that a non-noble gas-type ion such as the Cd^{2+} ion can interact more strongly with a S^{2-} ion than with an O^{2-} ion[29]. Due to the stronger mutual polarization, the heat of formation of the CdS_4 groups, i.e., the constituents of CdS crystals, should be greater than that of CdO_6 groups, i.e., the likely constituents of a glass which contains CdO. On cooling, when this energy difference between the Cd-S and the Cd-O bond becomes greater than the kinetic energy of the system, the statistical distribution of the anions will be replaced by one in which the S^{2-} ions combine preferentially with the Cd^{2+} ions. The tendency of the Cd^{2+} ions to surround themselves with S^{2-} ions rather than with O^{2-} ions leads to incompatibility at low temperature which in turn causes the nucleation of CdS (greenokite). The formation of CdS and, generally speaking, of a heavy metal sulfide is the result of the energy difference between the metal-sulfur and the metal-oxygen polyhedra rather than of the lattice energies of the crystals. This is revealed by the lack of influence of the melting point of the sulfide crystals on this phase separation. The separation of sulfidic ores from the original magma which contained both O^{2-} and S^{2-} ions can take place in the liquid state as can be seen from the forms of some ore deposits[29].

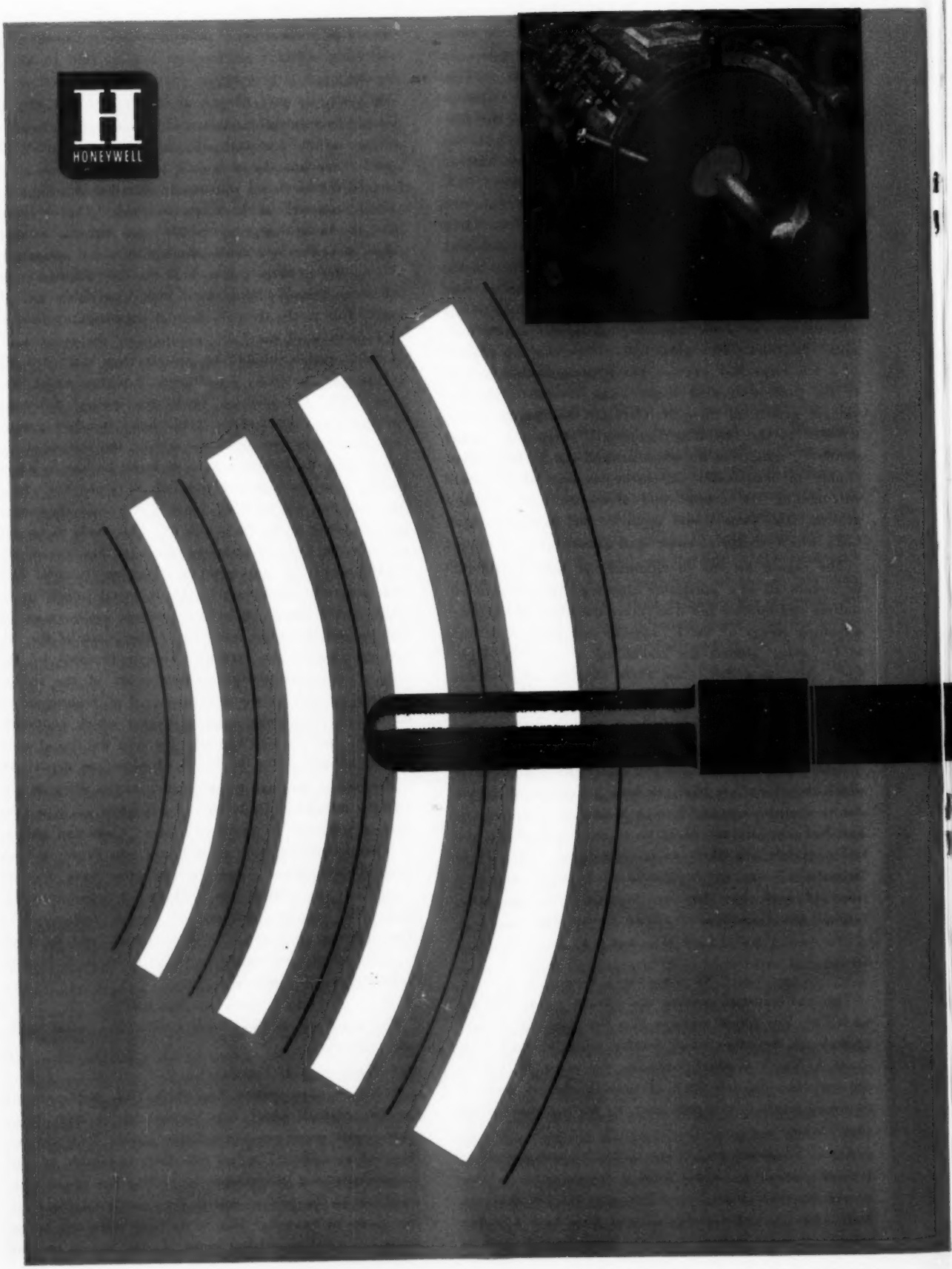
Because of the high polarizability of the S^{2-} and Se^{2-} ions the sulfides and selenides of non-noble gas-type ions have a tendency to develop defects. Cadmium sulfide is a semiconductor and as such one can expect a high rate of nucleation. Glass technologists have learned empirically to control the striking of selenium ruby glasses by minute additions of copper compounds[30]. The presence of some Cu^+ ions in a glass and the high chemical affinity of copper to sulfur is likely to lead to defective crystals such as

$$Cd^{2+}_{1-2x}\,Cu^{+}_{2x}\,(\text{An. Vac.})_x S^{2-}_{1-x}$$

The anion vacancies of such a defective crystal facilitate nucleation.

(d) Nucleation of Titania

In the ternary system Na_2O-SiO_2-TiO_2 stable glasses can be obtained which may contain up to 40% TiO_2. From some more complex silicate glasses TiO_2 crystallizes out as rutile. The fact that TiO_2 is soluble at high temperatures but precipitates on cooling has found technical use in the past primarily for opacifying low melting glazes or enamels. Due to its high refractive index, rutile is a good opacifying agent. Today, titania receives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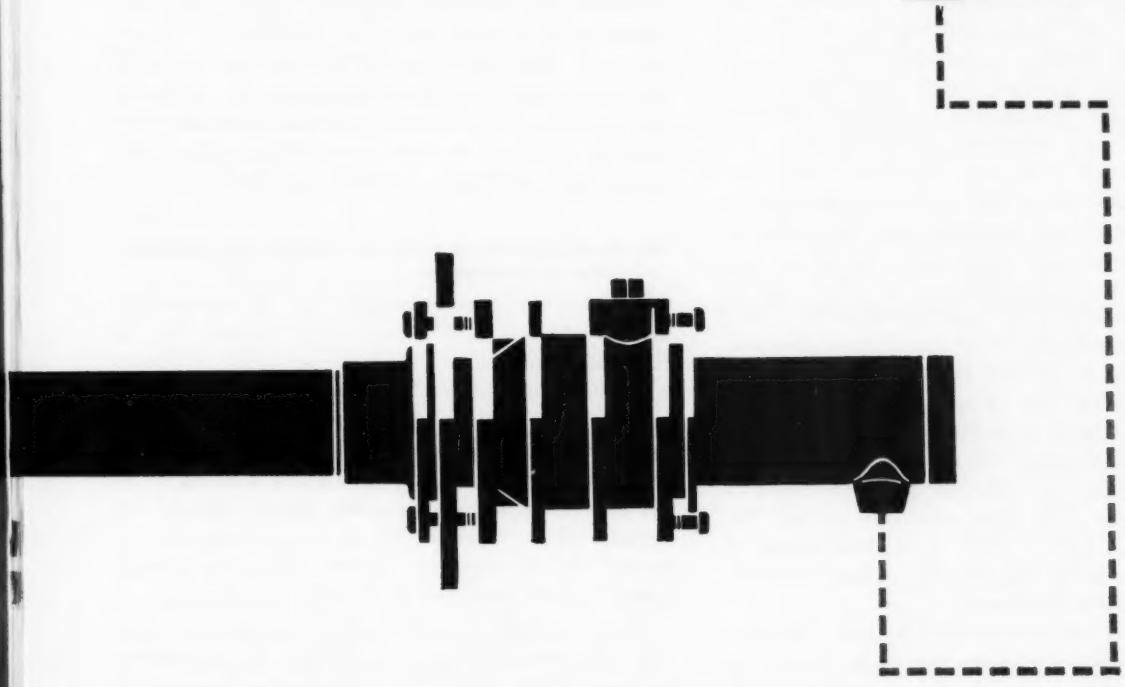

world wide attention because of Stookey's discovery[31] that TiO_2 can act as a catalyst for the formation of desirable crystalline phases which produce a ceramic material of high mechanical strength and low thermal expansion: pyroceram. This makes it interesting to speculate on the participation of TiO_2 in glass structures and the kinetics of its nucleation. Its precipitation from a silicate melt in itself is not surprising because TiO_2 has a high melting point and the phase diagram SiO_2-TiO_2 reveals its incompatibility with silica over a wide concentration range. The precipitation of oxidic compounds from a silicate glass usually leads to "stones" rather than to a finely and evenly subdivided phase which compares in its subdivision with the noble metals or with fluorides and sulfides.

We attributed the incompatibility of TiO_2 and SiO_2 to the different coordination requirements of the Si^{4+} and the Ti^{4+} ions. The size of the Si^{4+} ion (0.41 A.U) causes it to be well screened by four O^{2-} ions. The larger size of the Ge^{4+} ion (0.53 A.U) requires six O^{2-} ions for screening at ordinary temperature. GeO_2 has the structure of rutile. At higher temperatures, however, the rutile form of GeO_2 changes into a quartz like structure in which the Ge^{4+} ion is screened by four O^{2-} ions. The still larger Ti^{4+} ion (0.68 A.U) requires sixfold coordination up to the melting point of rutile. However, in a more polarizable environment it may well be that an equilibrium is established between TiO_6 and TiO_4 groups. Our interpretation of the viscosity of glasses[32] suggests that titania in sodium silicate glasses changes from fourfold to sixfold coordination as the temperature is lowered. Some recent work by A. Ram, S. V. Bhatye, and K. D. Sharma[33] on the viscosity of soda lime silicate glasses in which SiO_2 is partly replaced by TiO_2 can be interpreted on the same basis. The substitution of TiO_2 for SiO_2 in a representative soda lime glass was found to lower the viscosity in the high temperature region. The same substitution had no effect upon the viscosity at 800°C and it increased the viscosity at lower temperature, e.g., in the softening range.

A similar trend has been observed by L. C. Hoffman T. A. Kupinski, R. L. Thakur, and W. A. Weyl[34] for GeO_2 replacing silica in a sodium silicate glass. At high temperature this substitution lowers the viscosity but at 475°C the substitution of GeO_2 for silica had practically no effect upon its viscosity.

The tendency of cations to lower their coordination numbers with increasing temperature and vice versa is a well established feature in crystal chemistry. It could be demonstrated for Ni^{2+} and Co^{2+} ions that the same process occurs also in glasses[28]. Hence we may conclude that one reason for titania to precipitate on cooling from glasses which do not contain O^{2-} ions of sufficient polarizability to retain the Ti^{4+} ion in fourfold coordination would be its change of coordination from the high temperature TiO_4 form to TiO_6 groups which are stable at low temperature.

The basic difference in the form in which TiO_2 precipitates from glasses as compared with the devitrification of silica and silicates can be understood on the basis of the defect structure of TiO_2 which favors a high rate of nucleation. TiO_2 at high temperature assumes a structure which has vacant anion sites and this feature is conducive to a disproportionation of its binding forces which in turn lowers the activation energy of nucleation. The nucleation rate of TiO_2 is high because it precipitates as a defective structure whereas silica and silicates do not. Silicates and silica itself have low nucleation rates so that their precipitation from a glass is dominated by the growth rate of the few nuclei which form.

Other simple oxides, e.g., SnO_2, MoO_3, and WO_3, as well as the more complex vanadates, phosphates, and arsenates of lead behave very much the same as TiO_2. Compounds of this type form defective structures because they contain cations of high polarizability which are conducive to vacancy formation. Hence these compounds nucleate easily even at low temperatures. Ceramists have taken advantage of the ease of nucleation and precipitation of these compounds for producing opacity in glazes and enamels. Colored glazes have been made by applying the same principle to colored compounds such as $PbCrO_4$ (yellow) and Pb_2CrO_5 (red).

III. Enforcement of Glass Formation by Suppression of Nucleation

The fact that glass formation can be enforced by rapid cooling is well known. G. Tammann and A. Elbrächter[35] obtained extremely small beads of glasses when they quenched fused salts such as $AgNO_3$ or TlCl in the form of a spray. Binary alumina silica glasses are made commercially in the form of fibers. These refractory fibers have compositions which normally would not be considered to form stable glasses. We do not include glasses obtained by extreme chilling but we restrict our discussion to systems which form stable glasses in bulk quantities of at least several grams.

Hence, in order to enforce glass formation we have only one method, namely the change of composition. A change of the composition can aid glass formation in three ways:

1. Lowering of the Liquidus Temperature

The high stability of vitreous $K_2O{\cdot}4SiO_2$ or its reluctance to crystallize is the result of its low liquidus temperature which does not provide sufficient activation energy for the nucleation. The same applies to the stability of a lead orthosilicate glass. Even more convincing are the observations of G. W. Morey and H. E. Merwin[36] who observed glass formation for sodium orthoborate $2Na_2O{\cdot}B_2O_3$ but not for $Na_2O{\cdot}B_2O_3$. The melting point of $Na_2O{\cdot}B_2O_3$ (966°C) permits nucleation more easily than that of $2Na_2O{\cdot}B_2O_3$ (625°C). Thus in the system Na_2O-B_2O_3 they found a region of non-glass-forming compositions between two regions in which glass formation is possible. (*Continued on page* 49)

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PART VII

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"Physics of the Glassy State. I. Constitution and Structure," Am. J. Phys., 22, 43-53 (1954).

Modern views of the constitution and structure of inorganic glasses are outlined. Materials used in glass making are classified according to their role as network formers and network modifiers. Evidence of structure from x-ray scattering is reviewed. Examples of linear and non-linear dependence of specific volume on composition are presented, and the classical factors for composition dependents of heat capacity are related to quantum theory of specific heat.

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"Electron Microscope Investigation of Glass," Ind. Eng. Chem., 46, 147-53 (1954).

Twenty-nine direct transmittance electron micrographs, ten samples of silica, sodium oxide dry silica mixtures containing sixteen—fifty per cent Na_2O, both as produced and after controlled thermal treatment, and various commercial glasses are presented as evidence of structural inhomogeniety from 20 up to at least 200 A. in maximum dimension in glass. It is concluded that glasses containing micellar regions having a degree or order greater than that of the completely disordered random glass structure but less than that of the perfectly ordered crystals.

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"Physics of the Glassy State. IV. Radiation-Sensitive Glasses," Am. J. Phys., 22, 310-17 (1954); cf. C. A. 48, 6663d (1954).

Affects of radiation introducing color changes, often called solarization, in glass are described, and close analogy with modern work on F centers especially in alkali-halide crystals. For the sensitive glásses in which the action of radiation is to produce centers of nucleation around which collodial or crystalline precipitates can form are also discussed.

(To be continued in February)

Fall Glass Division Meeting Conclusion

Bedford Springs Hotel BEDFORD, PENNSYLVANIA, OCTOBER, 12-14 1960

Fluorine Release from Glasses

By *Louis Spanoudis* and *Josef Francl*, Kimble Division of Owens-Illinois, Owens-Illinois Technical Center, Toledo 1, Ohio. Presented by Mr. Spanoudis.

Fluorine release from glasses containing 0.075 per cent to 1.00 per cent fluorine content was studied in the temperature range 350°C-480°C. It was determined that the amount of released fluorine (in 10^{-6} gms. quantities) depended on glass composition and viscosity, temperature, and time. The experimental procedure was described, and a mechanism of fluorine evolution was proposed. The fluorine release may be effectively stopped by glass surface treatments.

It was concluded that:

1) Temperature dependence of fluorine release can be expressed by the equation:

$$\log F = (-A/T) + B$$

where: F = fluorine evolved (micrograms per sq. dm per hr.)
T = absolute temperature (°K)
A and B are constants.

Constants for six Kimble television glasses were reported.

2) Time dependence of fluorine evolution can be expressed by the equation:

$$F = m\, t^{1/2} + b$$

where: F = fluorine evolved (micrograms per sq. dm).
t = time (hours)
m and b are constants.

Constants for several temperatures were given for Kimble TM-5 glass.

3) Fluorine released is proportional to the fluorine content, only for glasses of the same viscosity and not containing lead or boric oxides.

4) Glasses with higher viscosities release less fluorine at any specific temperature. At the annealing point (temperature of same viscosity) glasses of the same general composition (without lead or boric oxide) release fluorine proportional to the fluorine content.

5) Glasses containing lead or boric oxide release more fluorine than similar glasses that do not contain lead or boric oxide.

6) Fluorine is released as hydrogen fluoride and alkali fluorides and not as fluorine gas or silicon tetrafluoride.

FRIDAY AFTERNOON

Chairman: HAROLD E. SIMPSON

State University of New York College of Ceramics, Alfred, N. Y.

The Iron Equilibria in Glasses: The Effect of Platinum on the Fe^{2+}/Fe^{3+} Equilibrium

By *Emery J. Hornyak* and *Tryggve Baak*, Fundamental Research Sec., General Research Div., Owens-Illinois Technical Center, Toledo, Ohio. Presented by Mr. Hornyak.

A series of experiments with iron containing sodium disilicate melts was run, both in platinum and alumina crucibles in an air atmosphere. In the alumina crucibles equilibrium was established in 3 hours, while in the platinum crucibles equilibrium was not attained even after 12 hours. These results, together with analogous work in other fields, definitely showed that platinum is unsuitable as refractory material in studies of iron equilibria in molten glass.

Thermodynamic calculations of the reaction

$$2\,FeO + \tfrac{1}{2}\,O_2 = Fe_2O_3$$

show that the standard free energy increases with increasing temperature. This behavior is opposite that for pure oxides where hematite exhibits decreasing stability with increasing temperature. The standard enthalpy and entropy were also calculated for the reaction.

It was also found that with increasing ferric iron concentration the deviation from ideality were considerable, which shows strong interaction between Fe^{3+} and the sodium disilicate melt.

The Constitution of Mixed Alkali Phosphate Glasses: II. The Constitution of Variable Lithium Constant Sodium-Potassium Phosphate Glasses

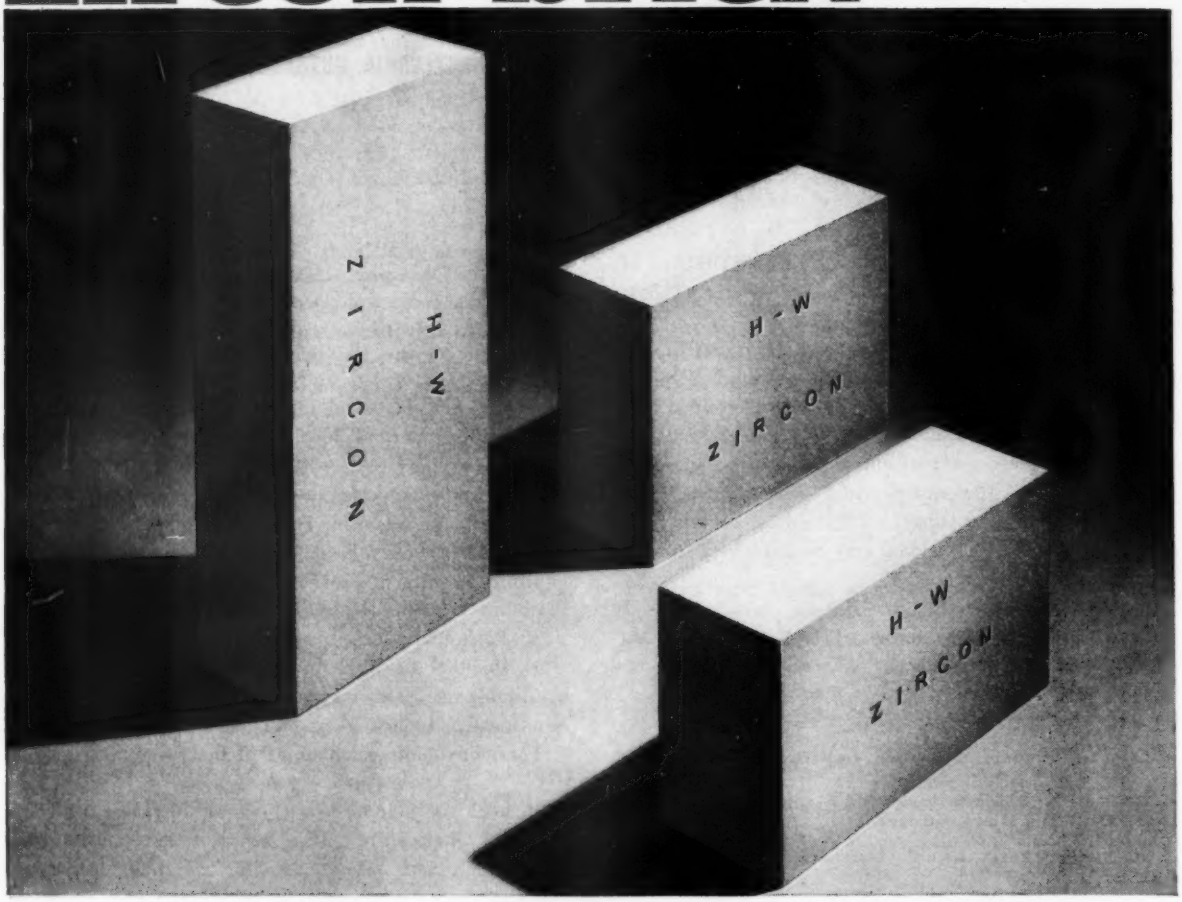
By *A. E. R. Westman* and *M. Krishna Murthy*, Ontario Research Foundation, Toronto 5, Ontario, Canada

In order to study the cationic influence of lithium, if any, the constitution of variable lithium constant sodium-potassium phosphate glasses was determined by means of paper chromatographic techniques. It was found possible to prepare glasses with very low $\bar{n}$, the number average chain length value. Glasses with $\bar{n}$ values of 2, 1.75, and 1.5 were prepared for glasses with Li:Na:K atom ratios of 1:1:1 and 2:1:1. Attempts

(*Continued on page* 47)

HARBISON-WALKER
zircon brick

zirconium silicate refractory

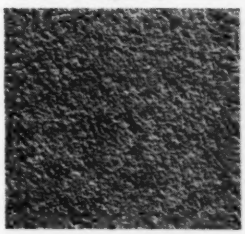


For paving Bottoms and Port Floors . . . and for positions of exposure to severe conditions above the glass line

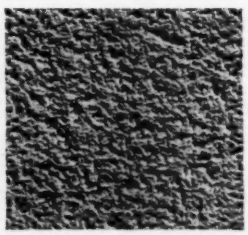
H-W ZIRCON brick, made from the mineral of high purity, in many rectangular sizes and shapes are formed by impact pressing. This method of manufacture contributes to the exceedingly desirable properties of density, homogeneous texture, both compressive and transverse strength and unusual precision in workmanship. Other physical properties of H-W ZIRCON possessed to the maximum degree are unusually high strength and stability of volume at high temperatures. Excellent resistance to thermal spalling and to severe fluxing conditions are additional properties of paramount importance for many applications.

The unusually high bulk density of H-W ZIRCON (average of 235 lbs. per cu. ft.), minute uniform pore structure with low porosity and permeability, account for its high resistance to impregnation by molten glass.

Sections of two commercial brands of zircon brick cut from standard sizes used for paving glass tank bottoms. Enlarged X2



This picture clearly shows the fine homogeneous texture of H-W ZIRCON brick.



Another commercial brand of zircon brick shows contrast in pore structure.

HW 60-19

HARBISON-WALKER REFRACTORIES COMPANY

AND SUBSIDIARIES *World's Most Complete Refractories Service*

GENERAL OFFICES: PITTSBURGH 22, PENNA.

Filament Winding

RADOMES AND MISSILE NOSE CONES

by W. G. Cox and H. L. Crispin, Brunswick Corporation

● FILAMENT-WINDING PROCESSES for fabricating fiber glass reinforced plastic structures have been developed and refined to fill the need for strong, rigid, electronically transparent radomes and missile nose cones with close dimensional tolerance. Temperature and shock loading problems associated with high altitude and high speed flight have been additional factors leading to this refinement. Previously radomes and missile nose cones were fabricated by conventional methods such as hand lay up vacuum bag or matched metal molding.

A number of advantages are realized in filament winding, where continuous fibers of resin-impregnated glass or quartz are wound on a pre-shaped mandrel. Rigidity and strength are the major improvements. Table I shows comparative results between conventional laminates and filament-wound parts.

In these days of high-accuracy electronic systems, a third very important factor is that of homogeneity, which is quite good in filament winding. This is, to a large extent, due to the accuracy with which the filaments can be placed upon the mandrel, and to the extremely close control on resin-to-glass ratio. Resin percentage may easily be held to ±1 per cent of the design.

Continuous glass or quartz filaments are normally pre-impregnated and stored in a refrigerator until ready for use. Then, under constant and controlled tension, the strands are wound upon a mandrel (Fig. 1) which has been coated with a mold release agent such as silicones. The modulus values resulting from uniform tension and continuous filaments approach those of pure glass and the absence of twisting and abrasion provides increased strength. For maximum loading efficiency, stress analysis is used to determine the direction in which the filaments are wound.

After winding, the part is cured in an oven of the same shape, for controlled heat input. It is ground to the proper electrical and/or physical tolerances (Fig. 2) after the curing process.

Equipment

Of course, the above procedure is greatly simplified. There are many mechanical refinements necessary to result in a good finished product. The winder must be able to place the filaments on the mandrel in a precise manner; oven temperature must be very closely controlled; and grinder accuracy is highly important.

A number of associated procedures and machines have been developed to help control the quality of the end product. These include the Vidagage, an ultrasonic physical thickness gage, and the one horn interferometer, a microwave electronic device used to measure the electrical thickness of the part before removal from the mandrel (Fig. 3).

Combining the interferometer results and those of the Vidagage, or other accurate physical measurements, a simple calculation yields the dielectric constant of the finished product. Variations of the dielectric constant are held to design ± 1/10.

(*Continued on page* 49)

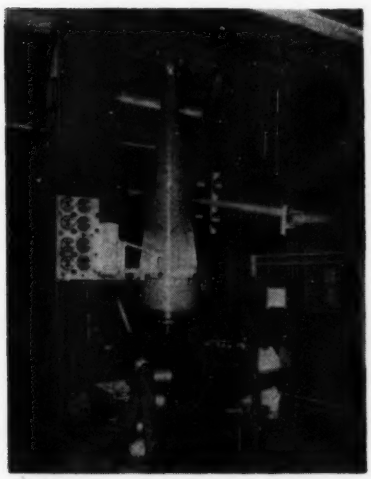


Fig. 1

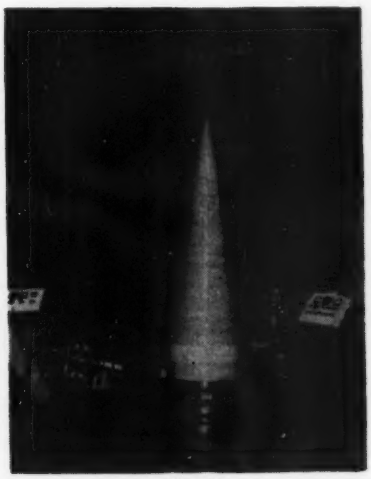


Fig. 2

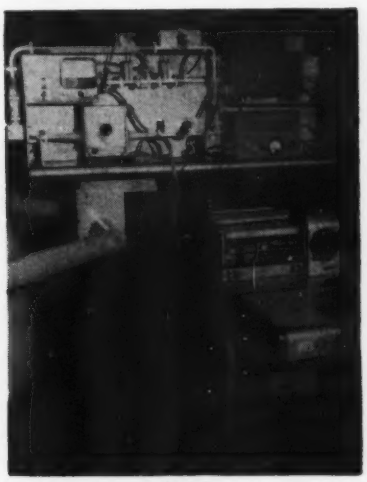


Fig. 3

FIG. 1. Fiber glass strands are wound upon a mandrel for missile nose cones. FIG. 2. Filament-wound fiber nose cone being ground to proper electrical/physical tolerances. FIG. 3. One horn interferometer measures electrical thickness of fiber nose cone (partial view at left)

NEWS

David J. Bender

David J. Bender

Chief industrial engineer for Johns-Manville Fiber Glass Division. He will supervise all industrial engineering for the company's seven manufacturing plants in the U.S.

Bender joined the predecessor firm, Glass Fibers, Inc., in 1952 as an industrial engineer. In 1955, when Glass Fibers became Libbey-Owens-Ford Glass Fibers, he was serving as engineering supervisor of the Defiance, O., plants. He retained tihs position until 1956 when he was named packaging and material handling engineer. He continued in that capacity after the company was acquired by Johns-Manville in 1958.

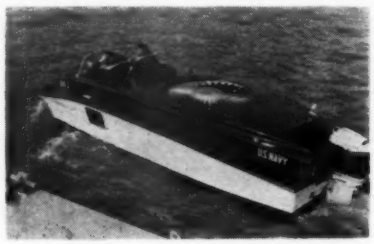
J-M's Fiber Glass Division produces fiber glass textile yarns and thermal-acoustical insulation materials for the industrial, commercial and residential fields.

Fiber Glass Boats

Some authorities predict that by 1963 approximately 65 per cent of all boats in the U.S. ranging from 6 through 60 feet in length will be of fiber glass reinforced plastic construction. If the past growth of the fiber glass reinforced plastic boat industry is any indication, this prediction is not an idle guess. From 1946 to 1953 production totaled only 4,000 units. By 1959, 83,000 fiber glass craft worth $1.5 million were produced. This was close to a 500 per cent increase over the 16,000 boats made six years before. In 1958 the marine field alone accounted for 15 per cent of the total consumers of reinforcel plastic products.

Increased production is not the only area of growth in the field. The inherent qualities of both fiber glass and plastic provide almost unlimited design possibilities. This advantage has been used not only in basic hull structures but in decks, deckhouses. flying bridges, submarine conning towers and fairwaters, and component parts such as chart table moldings, motor control boxes, shower stall floorpans, ventilation ducts, compass boxes, drinking glass racks, and antenna trunks.

An outstanding example of the future of fiber glass reinforced plastic boats to come is the "hydroskimmer." This experimental craft cruises over the water upon a cushion of air with its forward momentum supplied by a standard outboard motor. It was designed and built by Bell Aerosystems Company, a Division of Bell Aerospace Corporation, under contract to the U.S. Navy's Bureau of Ships. The 18 ft. long hull has an 8 ft. beam and weighs 2300 pounds. The large horizontally-



mounted fan amidships is driven by a small powerful motor. Air pushed down by the fan holds the hull above the water to reduce wave and frictional resistance. Using an outboard engine of approximately 70 h.p. the boat has attained a speed of 35 m.ph. Larger versions of this air-cushion principle craft could conceivably carry passengers and cargo across the ocean in less than a day.

——Durex Plastics Div., Hooker Chemical Corp., North Tonawanda, N. Y.

Merger Cancelled

Merger negotiations between Whitehouse Plastics Corp., Fort Worth, Texas, and Lunn Laminates, Inc., Huntington Station, L. I., N. Y., have been terminated by mutual agreement.

Ron Wallace

Ron Wallace

Is production manager for Automatic Plastic Molding Company, Berkeley, Calif. He is responsible for production, inventory, quality control, procuring of materials, and warehousing.

The company is a compression, injection, and fiber glass molder of products for a wide variety of industries.

Hooker Chemical Corp.

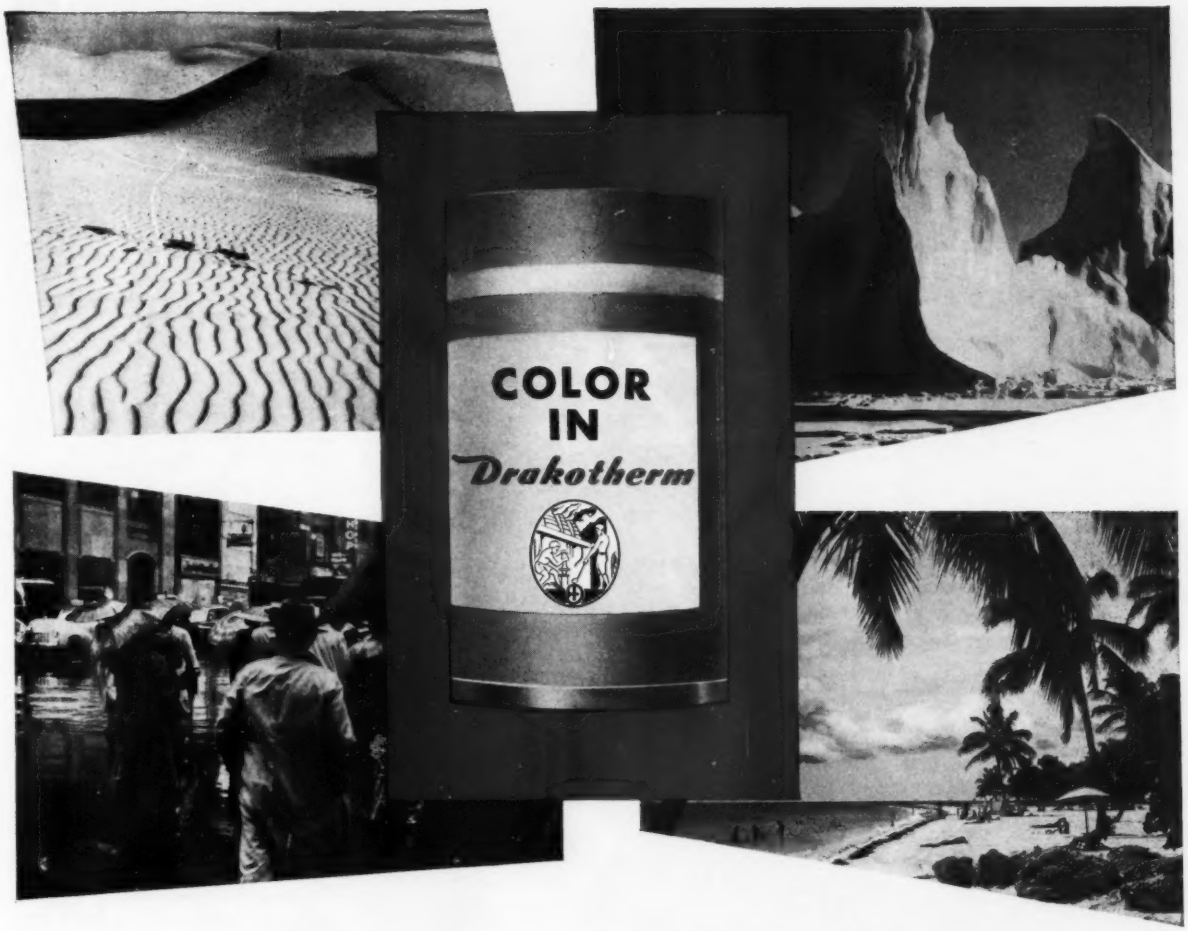
Elected Dr. Chris A. Stiegman and Charles C. Hornbostel vice presidents of research and development, and finance, respectively.

Owens-Corning Fiberglas

Has acquired a substantial minority interest in Fibreglass South Africa (Pty.) Ltd., producer of thermal insulation products. Other shareowners in the South African company are Plate Glass & Shatterprufe Industries, South African manufacturer of flat glass, and Fibreglass Limited, manufacturer of glass fiber products in England.

Fibreglass South Africa's line of glass fiber insulation products will be broadened by a development program using Owens-Corning patents and related technology. A modern production facility at Springs, Transvaal, is in the planning stage. It will produce glass fibers for the electrical and reinforced plastics industries.

There are fiber glass manufacturers in Canada, Japan, Mexico, Australia and New Zealand who are affiliated with Owens-Corning, and in several other countries companies are producing glass fiber products under license from Owens-Corning.



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Drakenfeld Colors in Drakotherm, the quick-setting thermoplastic printing paste, are the first choice of most glass container decorators. This medium is the result of nearly 10 years of research and plant experience in hot color printing by fully automatic machine.

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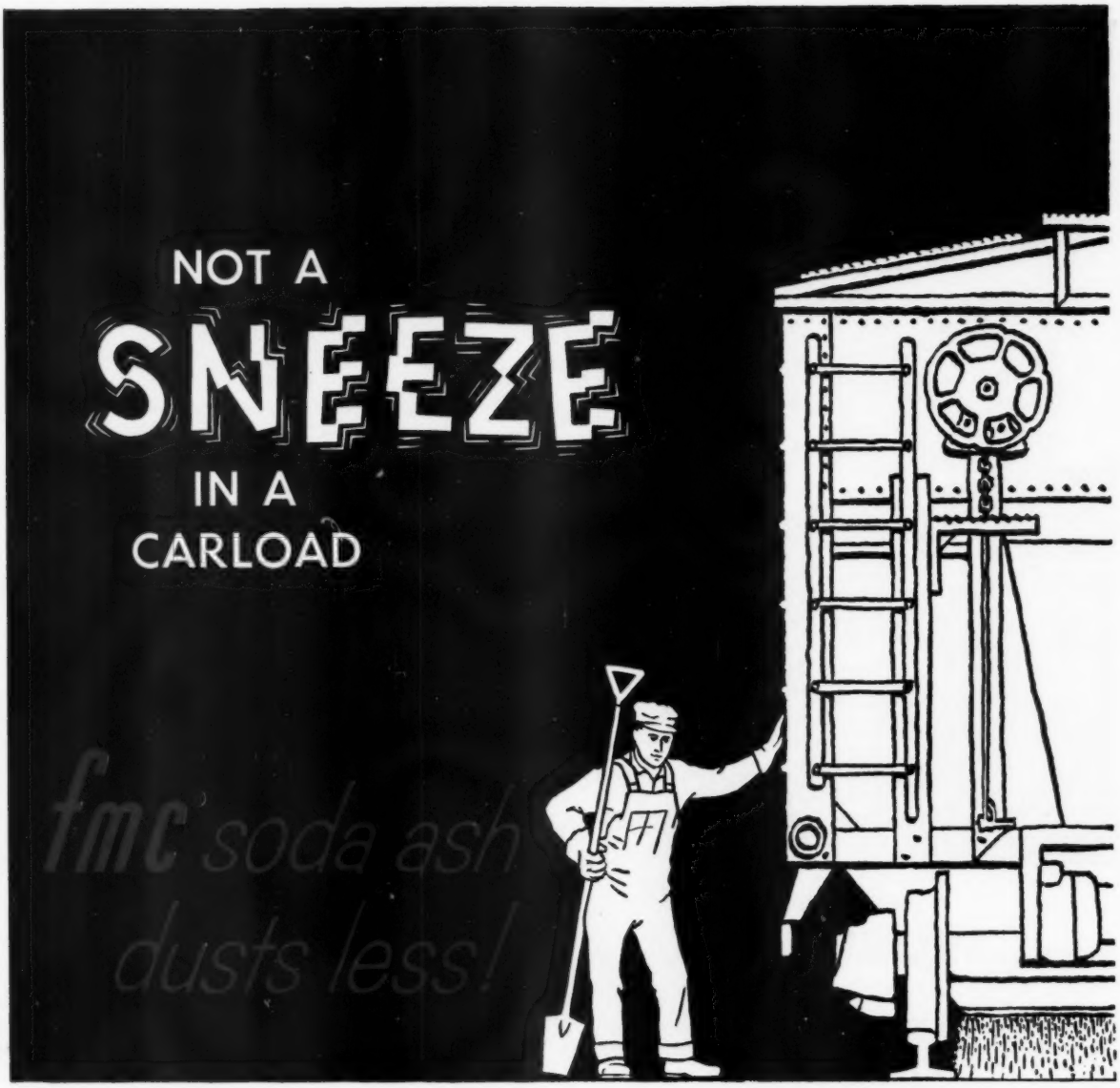

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FMC Soda Ash is made up of unique, needle-like crystals that resist break-down. They don't lump or stick . . . flow freely no matter what the weather.

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Premium quality FMC Soda Ash probably won't cost you a penny more, as our quote will show. Let's talk it over.

Putting Ideas to Work

FOOD MACHINERY AND CHEMICAL CORPORATION
Chlor-Alkali Division

General Sales Offices.
161 E. 42nd. STREET, NEW YORK 17

Applications...

FIBER GLASS SKYLIGHTS were installed in Pier 1 at Fulton St., Brooklyn, as part of the New York Port Authority's recently completed $85,000,000 waterfront redevelopment program. The 22,000 sq. ft. of skylighting diffuses natural light and blocks out harmful ultra-violet rays, therefore, perishables may be stored in cool, even light throughout the pier. The panels are corrugated to match the aluminum sheeting used for the roofing.

Panels: Barclite Corp., of America, 389 Gerard Ave., New York 51, N.Y.

VERTICAL LOUVER BLINDS of fiber glass coated on both sides with vinyl plastic and totaling 70,000 yards will be installed in the 64 story Chase Manhattan Bank Building now being completed in lower New York City. It is the tallest office building to be erected in 27 years.

The blinds consist of a series of vertically mounted, seven-inch louvers which may be traversed and rotated in unison for light control. The fiber glass furnishes three times greater breaking strength than cotton and it will not curl, twist, bow or distort under any conditions of hanging. The vinyl coated shade is flame and water resistant.

Vertical Blinds: Sun Vertical Blinds Co., Bellmore, L. I., N. Y.
Shade Cloth: E. I. du Pont de Nemours Co., Wilmington 98, Del.
Glass Fabric: Hess, Goldsmith & Co., Inc., 1400 Broadway, New York 18, N. Y., Division of Burlington Industries.
Glass Yarn: Owens-Corning Fiberglas Corp., Toledo, O.

FIBER GLASS reinforced plastic laminated bows were used by every one of 252 entrants in the 76th Annual Tournament of the National Archery Association of the United States.

One type of bow, the Bo-Tuff, consists of 70 per cent fiber glass and 30 per cent epoxy resin. The materials are combined in a lamination process employing approximately 180°F. heat and 90 pounds pressure

Fiber Glass: Johns-Manville Fiber Glass Corp., Toledo, O.
Processor: Gordon Plastics, San Diego, Calif.

FIBER GLASS HAIR DRYER is an attachment which is connected to an ordinary vacuum cleaner. The attachment looks like a large bonnet. A long hose connects it with the cleaner's blower attachment and warm air, cleaned through a series of fiber glass filters, is piped into the dryer.

Fiber Glass: Owens-Corning Fiberglass Corp., 717 Fifth Ave., New York, N.Y.
Fabricator: Lewyt Corp., Long Island City, L.I., N.Y.

FIBER GLASS SURFACING MAT incorporates the handling characteristics of a surfacing mat and the molding characteristics of a veil. It is said to be ideal for use where a deep-drawn part or a complicated shape is involved. The mat does not require molders to slip-sheet each layer. It is produced in thicknesses of 5, 10, 15, 20 and 30 mil with a polyester binder and silane finish.

Mat: Fameo, Inc., P.O. Box 35, Highland Park Station, Louisville 9, Ky.

PLASTIC COMPOUND of modified furfural alcohol reinforced with glass fibers is said to be highly resistant to practically all acids and solvents, and especially to alkalies, including hot, concentrated sodium and potassium hydroxide. It is capable of sustaining continuous operation temperatures to 300°F. The compound, with glass fibers, has proved successful in the processing of tanks, pipe and ducting.

Plastic compound: Developed by Beetle Plastics of Crompton & Knowles Corp., Fall River, Mass.

FIBER GLASS VS. PLANT CORROSION. Because of the ravaging corrosive effects of acid fumes, heat, humidity, moisture, fertilizer dust, and equipment vibration (See photo A.) fiber glass polyester panels were chosen to replace a building sheathing of zinc panels in the acid-processing section of

Photo A

a midwestern fertilizer plant. (See photo B.)

Before installation the fiber glass paneling was tested continuously for three years by actual plant exposure and immersion of sample strips in various acids at various temperatures. The panels use a corrosion-resistant, fire-retardant polyester resin, and provide top resistance to chlorine, phosphorous, and ammonium nitrate as well as to moisture, heat and humidity.

In addition to the 19,300 sq. ft. of fiber glass paneling the wall louvre equipment, gravity-type roof ventilators, flashing and trim are also reinforced fiber glass.

Polyester Resin: Durez Plastics Division, Hooker Chemical Co., Walck Rd., North Tonawanda, N.Y.

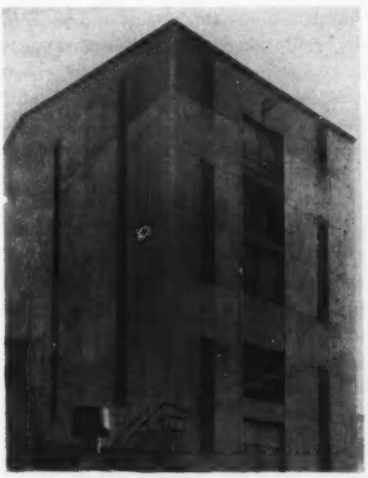
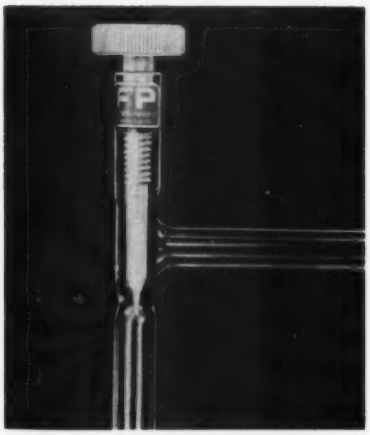


Photo B

NEW APPLICATIONS IN GLASS...



Threaded-Glass Needle Valve

A simplified two-piece construction features threaded-glass tubing which eleminates conventional metal threads, and a glass needle valve with a Kel-F stem and a wetted tip of Teflon. The valve has a maximum orifice of .05 inch and has been used successfully in vacuum applications down to 10^{-6} mm of mercury.

Glass Needle Valve: Fischer & Porter Co., 720 Jacksonville Rd., Warminster, Pa.

Hi-Temp Ceramic Insulations

Ceramic insulations capable of withstanding red heat temperatures of over 500°C have been developed for use in electrical systems for Mach 3 aircraft now under development, as well as for future missile and space applications. Inorganic sheet material consisting of a composite of flake mica and glass cloth bonded together with an inorganic cement are used for ground and phase insulators. Encapsulating insulators are formed with a ceramic cement which consists of equal parts of magnesium oxide and glass frit with a binder of aluminum phosphate in phosphoric acid. The cement has a pot life in excess of 30 minutes and shows less than one per cent moisture absorption after two hours immersion in boiling water.

In laboratory tests, the ceramic materials withstood 40 hours operation at 500°C, and remained in good operating condition after additional hours of testing at 300 to 500°C.

Insulators: General Electric Co., Schenectady 5, N.Y.

Glass Colors

New line of glass enamels in strong, bright colors and full matte finish. Available in many shades including vivid reds, oranges, yellows, blues and greens.

Pemco Corp., Baltimore 24, Md.

Laminated Architectural Glass

Features a plastic vinyl butyral interlayer with a variety of designs, textures, and colors. The laminated glass can reduce glare and ultraviolet rays and control light and solar energy. Construction is the same as that used in making bullet-resistant glass.

Plastic interlayer: Monsanto Chemical Co., Plastics Div., Springfield 2, Mass.

CATALOGS RECEIVED

Glass decorating. (13 pages) Illustrates the use of glass to dress up interiors, capture light, and lend spaciousness to rooms.

AMERICAN-SAINT GOBAIN CORP., 625 Madison Ave., New York 22, N. Y.

Construction Glass. (32 pages) This manual outlines the uses, qualities and specifications of numerous flat glass products available for construction.

Individual sections cover polished plate glass, window and safety glass, Vitrolux spandrel glass for curtain walls, bent glass, Tuf-flex doors, Mirropane transparent mirrors, bullet resistant glass and Parallel-O-Plate twin-ground glass for fine mirrors, residential window walls and commercial buildings.

LIBBEY-OWENS-FORD GLASS CO., Toledo 1, O.

Ceramic fiber. (8 pages) Brochure gives the properties, available forms, and current uses of ceramic fiber that withstands operating temperatures up to 2300°F. Uses include lehr roll covers in glass annealing and rolling, high-temperature furnace insulation and expansion-joint packing, insulation for furnace shafts and refractory rollers, component for ablation nose cone materials and missile antenna windows and electrical insulators in circuit breakers.

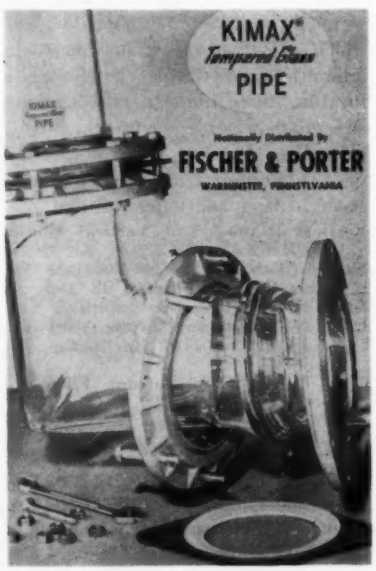
THE CARBORUNDUM CO., Ceramic Fiber Project, Research and Development Division, Niagara Falls, N. Y.

Custom produced glass. (20 pages) Illustrated. Step by step description of engineering and manufacturing service, from application analysis and formula development through mold design and custom-production. Special sections include: developing glass compositions for individual applications; controlling and combining the properties of glass; engineering products with specific characteristics—such as accurate and uniform colors, the right distribution of light, high physical strength, and thermal shock resistance; custom-production techniques; finishing operations that meet specialized needs; and testing and inspection.

KOPP GLASS, INC., Swissvale, Pa.

Glass pipe catalog. (36 pages) Features complete line of Kimax glass pipes, fittings, flanges, joints, gaskets, and miscellaneous hardware. Pipe sizes listed cover a range of one quarter inch to six-inches.

KIMBLE GLASS CO., Toledo 1, O.



New

B&W REFRACTORIES FOR THE GLASS INDUSTRY

B&W's line of refractories has been enlarged by the addition of new heavy duty firebrick and new ramming mixes. These new products, now offered after many years of developmental and field experience, are specifically designed for superior service in port necks and walls, regenerator walls and crowns, checkers, rider arches and burner blocks.

FIREBRICK

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KAO-HB

HIGH BURNED SUPER DUTY FIREBRICK

Fusion point 3220 F. This brick offers an excellent balance of properties to assure superior service. It provides approximately 5% more alumina content and lower total impurities than competitive brick. It has excellent spalling resistance.

KAO 60

60% ALUMINA FIREBRICK

Fusion point 3250 F. Provides higher hot load strength than any competitive brick. Spalling loss is only 1%.

KAO 70

70% ALUMINA FIREBRICK

Very low total impurities provide long life. Spall loss of only 2%.

RAMMING MIXES

★

MULRAM E

USE LIMIT 3200F
ALUMINA CONTENT–80%

This new ramming mix with extremely low permeability provides exceptional resistance to slag or molten metal penetration. High strength provides good erosion resistance.

MULRAM EF

USE LIMIT 3100F
ALUMINA CONTENT–80%

Similar to Mulram E but supplied in finer grain.

FOR COMPLETE PROPERTIES SHEETS and additional information on these new B&W Refractories products, write to The Babcock & Wilcox Company, Refractories Division, 161 East 42nd Street, New York 17, N. Y.

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B&W THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

NEWS
IN THE GLASS INDUSTRY

Personalities...

Dr. Eugene C. Sullivan

Bleininger Award

Dr. Eugene Cornelius Sullivan, Honorary Chairman of the Board and a Director of Corning Glass Works, has been named the recipient of the 1961 Albert Victor Bleininger Award, for distinguished achievement in the field of ceramics. The award is presented each year by the Pittsburgh Section of the American Ceramic Society.

Born in Elgin, Illinois, in 1872, and educated at the University of Michigan, the University of Gottingen, and the University of Leipzig, Dr. Sullivan is one of the outstanding scientists in the field of glass and ceramics.

He was the first full-time scientist to be employed by Corning Glass, and his original 1200 sq. ft. laboratory has grown into the Eugene C. Sullivan Research Laboratories with a total of 128,000 sq. ft. of floor space. At Corning Dr. Sullivan developed radically new manufacturing and testing methods as well as new markets for glass. He is best known for the development of borosilicate glasses which are used in Pyrex Brand cooking and dinner ware, and chemical glassware.

He was elected Honorary Chairman of the Board of Corning Glass Works in 1950. In addition he is Honorary Chairman of the Board, Dow Corning Corporation; Vice President and Director, Corhart Refractories Company; Director, Pittsburgh Corning Corporation; Director, Societe Industrielle des Silicones; Trustee, Corning Glass Works Foundation; and Trustee, The Corning Museum of Glass.

Dr. Sullivan holds an Honorary Sc. D. degree from the University of Michigan, the Perkin Medal of the Society of Chemical Industry, the Industrial Pioneer Award, and in 1928 he received jointly with Dr. W. C. Taylor the Howard N. Potts Medal of the Franklin Institute.

He is a Fellow of the American Ceramic Society and has been a member since 1917. He is an Honorary Fellow of the Society of Glass Technology, a member of the American Chemical Society, and the Electrochemical Society. He has served on various advisory boards, including Chairman of the Advisory Subcommittee of Glass of the U. S. Bureau of Standards.

Dr. Sullivan will receive the medal and scroll representing the award at the Albert Victor Bleininger Award dinner on Friday evening, March 10, 1961, at the Pittsburgh Athletic Association.

Richard W. Day,

H. Coleman Nichols, Jr., and Robert C. Roberts, Jr., have been transferred from special window glass sales to distributor sales at Libbey-Owens-Ford Glass Company. Day has been assigned to the Boston district; Nichols to New York; and Roberts to Toledo.

George Lass

Production superintendent of Corhart Refractories Company's new plant under construction at Buckhannon, W. Va. Frank W. Bush is business manager and Donald C. Fleming is plant industrial engineer and personnel manager.

George Lass

W. H. Goff

Elected to the newly created post of vice president in charge of manufacturing at The Phoenix Glass Company.

Louis B. Hart

Retired as district manager, Ferro Corporation, Los Angeles sales territory. Edwin B. Dietterle, head of ceramic glaze and color sales in the West Coast area will succeed him.

Roland R. Beach has been transferred from Los Angeles to New York. He replaces Bernard G. Murray who will transfer to the Color Division.

Philip H. McLaughlin

Named director of Marketing. Vitro Chemical Company. He will have full responsibility for all marketing activities, including sales, market research, market development and related programs, reporting directly to the president.

Donald C. Fleming

Frank W. Bush

Wilfrid Hibbert

Retires after 15 years of service with Libbey-Owens-Ford Glass Company. Most of that period Mr. Hibbert served as press relations manager. He will be succeeded by Everett Eakin.

Mr. Hibbert was on the staff of the Toledo Times from 1919 to 1941, serving the last three years as city editor.

Gordon H. Chambers

Resigned as Chairman of the Board, Foote Mineral Company. He has been with the company since 1928.

Gordon W. Howson

Will direct the new special products group established by Westinghouse Electric Corporation's lamp division. Two products which will be immediately assigned to the new organization are quartz heat lamps and ultraviolet lamps.

John W. German

Manager, building products sales, merchandising division of Pittsburgh Plate Glass Company. He succeeds George L. West who is retiring.

Edward W. Hufnagle is manager of automotive sales for the glass division. He will supervise the automotive glass sales office in Detroit, and will be responsible for glass division liaison operations with the automobile industry.

Wilfrid Hibbert

Everett Eakin

Thomas R. Francis

Manager of glass container sales to the drug and chemical industries, New York branch, Owens-Illinois Glass Company.

Nilsson S. Bassett

Formerly sales manager of Minneapolis-Honeywell Regulator Company's Industrial Systems Division, is now with the organization's Federal Services Group as marketing liaison with government agencies.

John O. Paull succeeds him as IDS sales manager. Paull's prior position as industrial sales manager of the Pacific region in Los Angeles will be assumed by J. F. Smith, the Southwest regional industrial sales manager at Dallas. R. E. Harris, district manager at Tulsa will succeed Smith.

Arthur S. Alexander

Joined the International Chemical Development and Operations Department, Food Machinery and Chemical Corporation.

Parker C. Finn

And Lawrence D. Stoddard, sales representatives for the Eastern sales district, Silicone Products Department, General Electric Company.

Kenneth M. Merz

Joined International Resistance Company as manager of ceramic research. Dr. Merz was formerly engaged in ceramic research for the Cornell Aeronautical Laboratory. Prior to that, he was associated with the Carborundum Company and the National Lead Company.

Companies...

Wilson Bros. Acquires Houze

Houze Glass Corporation, Point Marion, Pa., has been acquired from Thomas Mellon Evans, Pittsburgh industrialist and head of H. K. Porter Company and Crane company, in exchange for an undisclosed number of shares of Wilson Brothers common stock.

R. M. Pattison, president of Houze, and the present management will continue to operate the company as a subsidiary of Wilson. Houze produces a variety of colored technical and art glass, including pressed glass, colored machine-drawn glass, handblown colored flat glass, and fiber glass.

The most recent of its developments is a high-strength fiber glass product known as "Hi-Mod", which was developed for the U. S. Navy on a research and development contract and which is now available commercially. Its main uses are in the missile and aircraft field where its weight to strength ratio, approximately twenty times that of steel, is finding many applications.

Wilson Brothers is in the fiber glass business through its affiliate, Parallite Manufacturing Company, Export, Pa., which uses a technique of glass making and resin-impregnating that complements the Houze operations. Maurice Parker, chairman of the board of Wilson said that there will be an "immediate expansion of the plastics and glass fiber activities . . . utilizing the 260,000 sq. ft. Houze facility."

1st Electric Glass Furnace

Is being installed at the Chattanooga Glass Company, a subsidiary of the Dorsey Corporation. It is the first electric glass bottle furnace in the United States.

The $800,000 furnace is the initial step in an expansion program initiated by Dorsey, a New York investment company, when it purchased the Chattanooga firm.

Selas Corp. of America

Moved its Cleveland sales district headquarters to 6025 Mayfield Rd., Cleveland 24, O. T. G. Thurston is the district head.

October Construction Up

According to an F. W. Dodge Corporation report, The Dodge Index of construction listed 294 contracts for October, the highest level since April 1959. Contracts for non-residential buildings in October rose 16 per cent above the comparable month in 1959. Commercial building contracts led the way.

Hazel-Atlas Merger Approved

U. S. District Judge Frederick Van Pelt Bryan dismissed the Department of Justice's complaint charging Continental Can Company with violating the Clayton Act by its acquisition of Hazel-Atlas Glass Company.

In an interim decision read from the bench on December 8, Judge Bryan said that the government failed to prove or to establish that this merger of December, 1956, violated Section 7 of the Clayton Act. "The evidence adduced by the government is insufficient both qualitatively and quantitatively to establish that this acquisition has violated Section 7 of the Clayton Act in any respect."

General Lucius D. Clay, Board Chairman of Continental Can, said last month, "We have always been convinced that the acquisition of Hazel-Atlas has fostered rather than lessened competition, and therefore has contributed to the general welfare of industry. I consider Judge Bryan's decision a vindication of our judgment."

Marketing Conference

Bert Cremers, president, Wyandotte Chemicals International, Inc., and vice president-director, Wyandotte Chemicals Corporation, and John H. Reifel, vice president, Wyandotte Chemicals International, Inc., discussed four major areas of today's marketing function at the Marketing Management Conference, Nov. 10, sponsored by the University of Wisconsin Management Institute.

Mr. Cremers spoke about "What Management Needs at the Decision-Making Level" and "Long-Range Planning." Mr. Reifel discussed "Organization for a Planning Program" and "Coordinating a Program."

Quality Control Course

The Division of University Extension, University of Illinois, will present the fourteenth annual basic short course in Quality Control by Statistical Methods, January 30 through February 9. The course is designed to provide intensive work in the fields of control charts, acceptance sampling, and related topics for persons in the areas of design, production, procurement, management, quality control, and inspection.

For further information contact: Professor John A. Henry, Mechanical Engineering Laboratory, University of Illinois, Urbana, Ill.

Glass Melting Furnace

At Owens-Illinois Glass Company's Bridgeton, N.J., plant is expected to exceed the average 3½-year life expectancy of glass melting furnaces by two years, for a total production span of 66 months. At the end of this time the furnace will have produced 284,000 tons of flint glass—340 tons for each square foot of melting area.

Fairmount Glass Works

Began processing applied color label containers at the rate of 600 gross a day. The process is the latest service to be offered to the industry by the company. It is the final phase of the company's current $3,000,000 expansion which has extended over the past two years. Total production facilities have been increased by more than 50 per cent. Provisions have been made to double the applied color label production capacity within the new building prepared for the operation. The "ACL" process uses multiple colors.

Fairmount operates 21 glassmaking machines and has a production output of 1,500,000 containers daily. A 48,000 sq. ft. warehouse is being completed now and plans are under way to construct another of the same size.

Anchor Hocking Glass Corp.

And its subsidiary, Maywood Glass Company, Los Angeles, completed their merger.

The company's newly organized Western Division will manage all glass container and closure operations in the Western States from the Rocky Mountains to the Pacific Coast. The Division took over Maywood's operations, the Pacific Coast Closure Division's closure plant at South Gate, Calif., and the new glass container manufacturing plant in San Leandro, Calif.

Howard V. Fulton has been appointed vice president and general manager of the new division; R. H. Dallas is vice president in charge of sales; R. W. McKee is comptroller and assistant treasurer.

Plants of the Western Division manufacture flint, amber, emerald green and georgia green glass containers for food products, wines, liquors, beers, carbonated beverages, drugs, pharmaceuticals and household chemicals, as well as a complete line of closures for glass packages.

Industrial Opportunities in Ky.

The Kentucky Division of Industrial Promotion for the Department of Economic Development has published a new four-color, 52-page brochure outlining the state's advantages for new and expanding industry. The book describes Kentucky's transportation facilities; resources in power, natural gas, coal and other raw materials; new research facilities; and manpower. It also includes a description of the state's central location, high amount of public and private financing plans, and new business and governmental climates.

Copies may be obtained from the Division of Industrial Promotion, 320-N4 State Capitol Bldg., Frankfort, Ky.

Pfaudler Permutit, Inc.

Has formed a new Brazilian company called Pfaudler Permutit Beneficiamento De Fluidas, LTDA, to be located in Sao Paulo, Brazil.

Dr. Ernesto E. E. Geiger will direct the new firm which becomes a part of the parent company's International Division. The Brazilian company will be primarily occupied with engineering, subcontracting and importing Permutit water conditioning equipment for the Brazilian market. The firm will also investigate the desirability of establishing facilities for manufacturing glass and/or plastic lined vessels in Brazil.

The Pfaudler Permutit company manufactures a wide range of glassed steel and alloy equipment for the process industries, as well as chemicals and equipment for industrial and household water treatment.

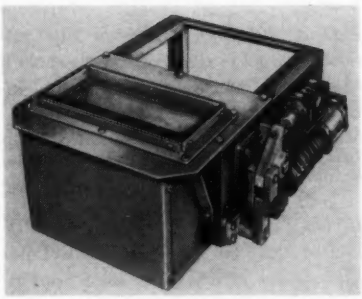
Molybdenum Deposit

Molybdenum Corporation of America has confirmed the existence of a large molybdenum deposit located on company owned property near Questa, N.M.

Molybdenum's high melting point, exceptional thermal-shock resistance, good electrical conductivity and resistance to corrosion in certain mediums have resulted in its consideration and use in electrical, electronic, nuclear, and other areas important to the United State's defense program. The metal has become increasingly important to the Nation's space, missile and industrial programs. In 1959 the free world consumption was about 60 million pounds.

At present, 80 to 90 per cent of molybdenum's use is in iron and steel alloys where it imparts added strength.

NEW EQUIPMENT AND SUPPLIES



Gravity Feeder

Precision-built feeder for feeding and batching of free flowing non-flooding materials. Features fast, slow, and dribble flow speeds. A pneumatic vibrator mounted on the flow control gate is actuated when slow or dribble flow is desired thus assuring an even flow of material through the gate.

Device was designed to feed materials with particles up to ¼-in. in diameter.

John S. Blackwell, Thayer Scale Corp., Thayer Park, Pembroke, Mass.

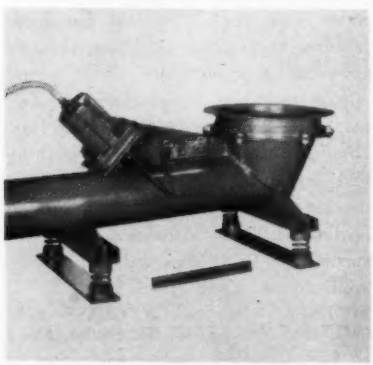
Enclosed Vibrator

Totally enclosed air-powered vibrating conveyor said to eliminate contamination and dust when moving bulk materials. The aluminum tubular conveyor which carries the material is powered by an air-cushioned vibratory drive for quiet operation. Vibration is isolated from surrounding structures by four coil springs.

Flow is started and stopped by a quick-acting valve which can be regulated by adjusting the air supply.

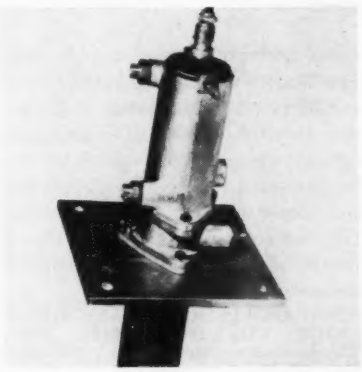
The unit is three feet long and has a six inch diameter conveyor tube. Longer units are possible by telescoping individual conveyors in series. Conveyors up to 20 feet in length may be powered by a single unit. Air pressure from 10 to 100 lbs. can be used for operation. No motors, belts, bearings, eccentric, gears or spiral screws are used and the one moving part, a piston inside the cylinder, is automatically lubricated.

The Cleveland Vibrator Co., 2828 Clinton Ave., Cleveland 13, O.



Glass Surface Pyrometer

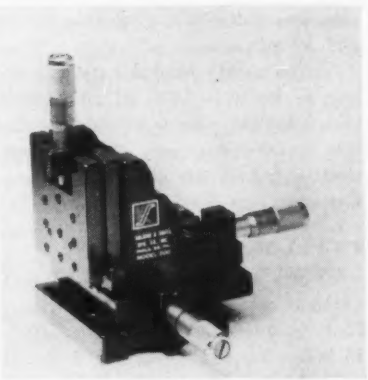
A radiation pyrometer with a thermopile as a detector. The instrument uses an optical filter to limit its response to the infra-red band between 4 and 8 microns, and errors from glass transmission or reflection are negligible.



Atlantic Pyrometers, Inc., 190 Warburton Ave., Hawthorne, N.J.

Micro-Positioner

Designed to provide smooth, accurate and quick positioning in three planes—X, Y, and Z. This micro-positioner can be used wherever it is necessary to accurately control the movement into position of either a part or tool. It is particularly useful in the manufacture of semi-conductors and electronic tubes.



It can be used in physical, biological, medical, and experimental laboratories.

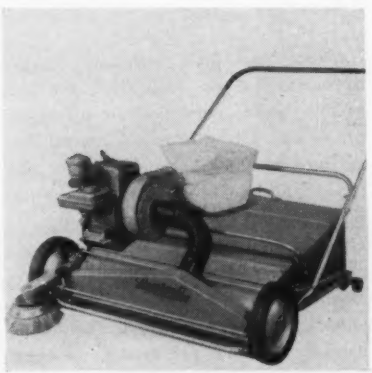
The instrument has a .500 inch range in both horizontal and vertical planes. A .001 inch range is standard and .0001 inch and metric range micrometers can be specially ordered.

Kulicke & Soffa Mfg. Co., 1234 Callowhill St., Philadelphia 23, Pa.

Dustless Floorsweeper

This maneuverable floorsweeper is equipped with a floating floor seal for controlling fine dust. Combination vacuum and sweeping action cleans dirt, dust and heavy debris. Dust is trapped in a vacuum bag and heavier debris is swept into a giant steel hamper by a main brush.

Lambert Inc., 519 Hunter Ave., Dayton 4, O.



Lab Flasks

Different sized flasks with capacities from 25 to 4,000 ml designed to increase efficiency and broaden use of chemical glassware. A plastic thread screw cap is available on eight different sized flasks with capacities from 25 to 2,000 ml. The cap is resistant to alkali attack and prevents leakage and contamination.

A flask with an expanded open end which facilitates transfer of crystals, salts and powders is offered in the 25 and 50 ml. sizes.

Narrow mouth beaded ware is available in the 10 to 4,000 ml. sizes; wide mouth beaded ware is available in the 500 or 1,000 ml. sizes. All flasks are made of borosilicate glass.

Corning Glass Works, Corning, N.Y.

CATALOGS RECEIVED

Recorders and indicators. (48 pages) Catalog describes strip and circular chart recorders and precision indicators. Includes a quick changing 2 to 24 point Multipoint recorder.

MINNEAPOLIS-HONEYWELL REGULATOR CO., INDUSTRIAL DIV., Wayne and Windrim Aves., Philadelphia 44, Pa.

Equipment catalog. (64 pages) Gives engineering specifications, technical drawings, and suggested usages of electrical, hydraulic, and mechanical items used for original manufacturing or maintenance in a wide range of industries.

GROBAN SUPPLY CO., Dept. 601, 1139 South Wabash Ave., Chicago 5, Ill.

Pyrex labware. (316 pages). Publication gives detailed product information on 9,000 laboratory apparatus items. Contains illustrations of all apparatus and chemical ware. Color-coded for quick and easy reference.

CORNING GLASS WORKS, Laboratory Glassware Sales Dept., Corning, N.Y.

Unitized liquid-level switch. (4 pages) Specifications are described for this switch, which combines an ultrasonic probe and a transistorized control into an integral unit. The folder states that the liquid-level sensor, acting as an integral unit or a separate unit, is capable of monitoring a large number of liquids, including cryogenic liquids, chemicals and petroleum products. Other applications include liquid-level control in food processing, beverage and dairy products, and all aqueous systems; and propellant utilization, loading control and monitoring.

ACOUSTICA ASSOCIATES, INC., 600 Old Country Rd., Garden City, N.Y.

Railroad car shaker. (6 pages) Describes a low-frequency vibration shaker mechanism for fast, economical unloading of hopper bottom cars at the rate of 8 to 10 cars per hour.

LINK-BELT CO., Dept. PR. Prudential Plaza, Chicago 1, Ill.

Diamond data. (Vol. 1, Nos. 7-8) Technical periodical. Describes evaluation tests which demonstrated the strong correlation between particle shape and efficiency in resin-bonded diamond grinding wheels. Preliminary data from continuing tests indicates a similar correlation existing in metal-bonded wheels, but with greater efficiency resulting from particles of different shape.

INDUSTRIAL DIAMOND DIV., ENGELHARD HANOVIA, INC., 75 Austin St., Newark 2, N.J.

Pelletizing and mixing discs. (4 pages) Describes a standard line of rotating discs for pelletizing or mixing materials such as ore fines, phosphates, ceramic clays, fly ash and oxides. Includes information about the size and quality of pellets produced and the overall cost per ton of output.

DRAVO CORP., Neville Island, Pittsburgh 25, Pa.

Filled system thermometers. (12 pages) Specification sheet covers bulbs, tubing, and fittings for filled system thermometers. Detailed information is given concerning sizes, lengths, materials, etc., for bulbs and tubings of gas, mercury, and vapor-actuated thermal systems. Vibration-resistant gas-actuated thermal system, which uses miniature bulbs, is also covered.

MINNEAPOLIS-HONEYWELL REGULATOR CO., INDUSTRIAL DIV., Wayne and Windrim Aves., Philadelphia 44, Pa.

Fireclay refractories. (8 pages) This brochure features specific refractory brands for medium-duty service, high-duty service and superduty service. Included are: property descriptions; data on P.C.E. test, panel spalling test and load test results; and information on the mineral deposits, plants, warehouses and offices that serve the west coast states. Contains descriptions and photos of manufacturing operations.

HARBISON-WALKER REFRACTORIES CO., Pittsburgh 22, Pa.

Rare earths. Data sheets on the use of rare earths and allied elements in dielectric ceramic materials.

VITRO CHEMICAL CO., 342 Madison Ave., New York 17, N. Y.

Laboratory glass. (108 pages) Catalog lists such items as distilling flasks, round-bottomed, short-ringed neck boiling flasks, pipets, and stopcocks. Price list included.

KIMBLE GLASS CO., Toledo 1, Ohio.

Bellows differential pressure transmitter. (4 pages) Specification sheet with illustrations and diagram. Ordering information is included.

MINNEAPOLIS-HONEYWELL REGULATOR CO., Industrial Div., Philadelphia 44, Pa.

Ceramic research. (14 pages) Description of frit and its applications. Color illustrations of inorganic color applications. Story of company's growth and operations.

PEMCO CORP., 5601 Eastern Ave., Baltimore 24, Md.

Glass-working lathe chucks. (2 pages) Gives specifications and prices; describes important features of the Westcott handwheel actuated self-centering chuck designed specifically for glass work. Ordering instructions for the chucks and adapters are included.

ONEIDA MACHINE TOOL CORP., 320 E. Walnut St., Oneida, N.Y.

Forehearth temperature controls. Data sheet describes methods of improving gross pack; lessening rejects through close control of glass temperature despite changes of load, weight, fuel or ambient temperature.

MINNEAPOLIS-HONEYWELL REGULATOR CO., Wayne and Windrim Aves., Philadelphia 44, Pa.

Glass machinery for flat glass. (128 pages) Describes operation, overall dimensions, power supplies, component parts, and applications of automatic beveling and edging machines, abrasive belt machines, diamond wheel pencil edging machines, mirror face cleaning machines, grinding mills, cutting machines, polishing machines, washing and drying machines, mirror silvering machines, and many others. The catalog is illustrated and includes a section of special machines designed for specific applications. Catalog No. 1161.

SOMMER AND MACA GLASS MACHINERY CO., 5501 W. Ogden Ave., Chicago 50, Ill.

INVENTIONS AND INVENTORS

Glass Composition

Glass Composition. Patent. No. 2,946,694. Filed June 2, 1958. Issued July 26, 1960. No drawings. Assigned to L. O. F. Glass Fibers Company, by Dominick Labino.

The present invention is concerned with the attaining of a glass which has a reasonably low viscosity in the working range; a temperature range in which the viscosity does not change unduly throughout the range and in which range the glass is workable for production of the fibers; a high melting rate; a low liquidus temperature with relation to the temperature at which the glass is usually worked; a suitable fiber-forming viscosity or fluidity at low temperature, which permits high production rates; a low devitrification rate, which inhibits devitrification when the glass is quickly cooled as at the orifices of the fiber-forming apparatus.

Batch compositions within the scope of the invention and the percent calculated oxide composition of the glasses formed therefrom are listed in Table I.

Table I

Batch Weights	No. 1	No. 2	No. 3	No. 4	No. 5
Lithium Carbonate	6.76	2.00	3.90	8.00	2.00
Aluminum Hydrate	20.70	16.00	27.86	20.70	16.00
Boric Acid	16.60	20.00	19.60	16.60	16.60
Cryolite	15.40	15.40	12.00	12.00	15.40
Sodium Phosphate (Na_3PO_4)	40.54	46.60	36.64	42.70	50.00
Percent Calculated Oxide Composition:					
Al_2O_3	21.3	17.0	28.8	20.5	16.7
Na_2O	36.6	39.4	33.0	36.6	41.0
Li_2O	3.4	1.0	2.0	4.0	1.0
B_2O_3	11.5	13.4	13.9	11.6	10.9
P_2O_5	21.1	23.5	19.5	22.4	24.7
F_2	10.4	10.0	8.3	8.1	9.7
	104.3	104.3	103.5	103.2	104.0

There were 5 claims and the following references cited.

United States Patents

2,577,627, Pincus, Dec. 4 ,1951.

Foreign Patents

498,049, Great Britain, Jan. 3, 1939; 941,885, France, Jan. 24, 1949.

Glass Compositions and Method of Making Same. Patent No. 2,901,362. Filed July 27, 1948 (originally) and May 18, 1955 (this application). Issued August 23, 1955 (originally) and August 25, 1959 (this patent). No sheets of drawings; none reproduced. Assigned to American Optical Company by Alexis G. Pincus.

The invention is directed particularly to the combining of BeF_2 (beryllium fluoride) or equivalent substituents $(PO_3)^-$ (the metaphosphate radical) or equivalent substituents, and R^+ (an ingredient or ingredients of the metallic cations group) in such a manner as to obtain glasses having low or variable and controllable indices of refraction, low or variable and controllable optical dispersions, controlled as to stability and resistance to chemical attack and weathering. Also controllable characteristics to melting and softening properties which introduces ease of fabrication and possesses practical working and remelting characteristics.

A useful glass composition has been found to be made from the batch 40 per cent (by weight) beryllium fluoride, 40 per cent (by weight) cryolite, and 20 per cent (by weight) sodium metaphosphate.

Glasses of the present invention open an entirely new field of research as to optical systems and lens design in general and lend themselves to several different applications. For examples of particular uses: such glasses may replace crystals in highly corrected lens systems; may be used as an intermediate medium for supporting the elements of different lens systems in more positive relation with each other and at the same time replace the conventional air spaces of the elements of such systems with a less abrupt interfacial transition in refractive indices; and will afford other design possibilities which can take advantage of their unique optical characteristics.

There were 13 claims and the following references cited in this patent.

United States Patents

2,481,700, Sun et al., Sept. 13, 1949; 2,716,069, Pincus, Aug. 23, 1955.

Other References

Blau et al.: THE GLASS INDUSTRY, February 1935, page 54.

Sheet and Plate Glass

Treating Glass Sheets. Patent No. 2,941,336. Filed September 20, 1957. Issued June 21, 1960. One drawing; not reproduced. Assigned to Pittsburgh Plate Glass Company, by Guy C. Devore.

This application covers improvement in bending molds for bending elongated glass sheets having pointed extremities to minimize tip curling and tip breakage.

The invention provides a structure for glass bending molds that inhibits tip curling and also permits the mold tips to cool rapidly enough between successive bending cycles to avoid the necessity for a large inventory of bending molds for each production item or the employment of techniques tending to warp the molds.

(*Continued on page* 50)

CURRENT STATISTICAL POSITION OF GLASS

Employment in the glass industry during September, 1960, was as follows: *Flat Glass:* a preliminary figure of 25,900 for September, 1960, indicates an increase of 1.5 per cent over the adjusted figure of 25,500 reported for August, 1960. *Glass and Glassware, Pressed and Blown:* an increase of 1.5 per cent is shown by the preliminary figure of 92,200 reported for September, 1960, when compared with the adjusted figure of 90,800 reported for August, 1960. *Glass Products Made of Purchased Glass:* the preliminary figure of 14,000 given for September, 1960, is 1.5 per cent over the adjusted figure of 13,800 reported for August, 1960.

Payrolls in the glass industry during September, 1960, were as follows: *Flas Glass:* an increase of 1.8 per cent is shown in the preliminary $14,121,234.00 given for September, 1960, when compared with August's $13,857,843.93. *Glass and Glassware, Pressed and Blown:* a decrease of 0.2 per cent is shown in the preliminary $36,454,612.25 given for September, 1960, when compared with the previous month's adjusted $36,534,504.10. *Glass Products Made of Purchased Glass:* a preliminary figure of $4,702,518.24 was reported for September, 1960. This is an increase of 5.5 per cent when compared with the adjusted figure of $4,453,561.39 for August, 1960.

Glass Container Production based on figures released by the Bureau of the Census, Industry Division, was 13,968,000 gross during October, 1960. This is an increase of 8.2 per cent over the previous month's production figure, 12,899,000 gross. During October, 1959, glass container production was 13,508,000 gross, or 3.2 per cent under the October, 1960 figure. At the end of the first ten months of 1960, glass container manufacturers have produced a preliminary total of 137,330,000 gross. This is 5.2 per cent more than the 130,437,000 gross produced during the same period in 1959.

Glass Container Shipments during October, 1960, came to 12,998,000 gross, a decrease of 8.3 per cent under September, 1960, which totaled 14,170,000 gross. Shipments during October, 1959, amounted to 12,159,000 gross, or 6.5 per cent under October, 1960. At the end of the first ten months of 1960, shipments have reached a preliminary total of 133,243,000 gross which is 0.6 per cent more than the 132,441,000 gross shipped during the same period of the previous year.

Stocks on hand at the end of October, 1960, came to 20,890,000 gross. This is 4.9 per cent over the 19,907,000 gross on hand at the end of September, 1960, and 4.8 per cent more than the 14,113,000 gross on hand at the end of October, 1959.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers

	October, 1960
Food	1,444,000
Medicinal and Health Supplies	1,522,000
Chemical, Household and Industrial	971,000
Toiletries and Cosmetics	962,000
Beverage, Returnable	454,000
Beverage, Non-returnable	116,000
Beer, Returnable	63,000
Beer, Non-returnable	798,000
Liquor	1,110,000
Wine	464,000
Sub-total (Narrow)	7,904,000

Wide Mouth Containers

Food	*3,953,000
Medicinal and Health Supplies	402,000
Chemical, Household and Industrial	163,000
Toiletries and Cosmetics	270,000
Dairy Products	147,000
Sub-total (Wide)	*4,935,000
Total Domestic	12,839,000
Export Shipments	*159,000
TOTAL SHIPMENTS	*12,998,000

* This figure includes Fruit Jars, Jelly Glasses, and Packers' Tumblers.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production October 1960	Stocks October 1960
Food, Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics	Narrow Neck	5,082,000	7,015,000
	Wide Mouth	*5,141,000	*6,870,000
Beverage, Returnable		624,000	2,407,000
Beverage, Non-returnable		168,000	349,000
Beer, Returnable		104,000	493,000
Beer, Non-returnable		1,073,000	1,108,000
Liquor		1,134,000	1,624,000
Wine		485,000	717,000
Dairy Products		157,000	307,000
TOTAL		*13,968,000	*20,890,000

* This figure includes Fruit Jars, Jelly Glasses, and Packers' Tumblers.

GLASS DIVISION MEETING

(*Continued from page* 31)

to prepare a glass with n value of 1.25 were unsuccessful. At higher lithium concentrations it was not possible to prepare glasses with low $\bar{n}$ values.

The constitution of lithium phosphate glasses was also reinvestigated. Contrary to the observations of previous investigators, it was found that the lithium glasses are readily soluble in 1(N) sodium bicarbonate solution. However, values obtained for the lithium glasses were in good agreement with the previous results obtained and were considerably different from the sodium glasses.

A comparison of the constitutions of mixed cation phosphate glasses and lithium glasses indicated small but definite cationic effect. The significance of these results in relation to Van Wazer's polymer theory and distribution laws was discussed.

The Influence of Platinum Nucleation on the Constitution and Structure of Sodium Phosphate Glasses

By *M. Krishna Murthy,* Department of Chemistry, Ontario Research Foundation, Toronto 5, Ontario, Canada

Published work in the literature indicates that small amounts of platinum bring about phase separation in sodium phosphate melts, which can be recognized in electron micrographs of the freshly fractured surfaces of the glasses. This has been called microphase separation.

Macrophase separation in alkaline earth-silica systems has shown that the phase separation is a chemical process because the two separated phases have different chemical compositions. Since it is known that the constitution of sodium phosphate glasses is a function of sodium/phosphorus ratio, it was expected that phase separation in an alkali phosphate melt would also affect its constitution.

The influence of 0.0038, 0.0076, 0.038, and 0.15 weight per cent of platinum on the constitution and structure of sodium phosphate glasses, with $\bar{n}$ varying from 3 to 9, was investigated using both paper chromatographic and electron microscopic techniques. The results indicated that although platinum nucleation brings about microphase separation, the constitutions of the sodium phosphate glasses studied were not affected.

Two alternative explanations for the similarity in the constitutions between the nucleated and non-nucleated glasses were presented.

Gamma Irradiation Studies of Some Borate Glasses*

By *Adli Bishay,* Resident Research Associate, Remote Control Engineering Div., Argonne National Laboratory, Argonne, Illinois. On leave of absence from The American University at Cairo, Egypt.

The gamma ray induced optical absorption in a series of Cabal (calcium-boron-aluminum) glasses was studied and interpreted, wherever possible, in terms of structural concepts. A resolution of the observed absorption spectra showed that three gaussian shaped bands were induced with their maxima at about 2.3, 3.5, and 5.0 ev (550, 350, and 250 m μ). The intensity of the 2.3 ev band did not show a regular relationship with the changing structure of the glass. The intensity of the 3.5 ev band decreased gradually with increasing mole per cent of CaO and increased with increasing Al_2O_3. The 5.0 ev band showed an abrupt increase in intensity, which corresponded to the appearance of nonbridging oxygens in the network. Replacing Ca^{++} by Mg^{++}, Sr^{++}, or Ba^{++} or replacing Li^{+} by Na^{+} or K^{+} showed that glasses containing large ions of low field strength give less induced absorption than glasses containing small ions of high field strength.

A potassium alumina borate glass melted under reducing conditions gave a considerably higher U.V. transmission, before irradiation, as compared to the same glass melted under normal conditions. The gamma induced absorption of these two glasses showed that reducing conditions resulted in a decrease in the intensity of the 2.3 and 3.5 ev bands, while it caused an increase in the far U.V. induced absorption.

Glass Scintillator for Neutron Detection

Also presented by Mr. Bishay.

A glass scintillator which can be used as one of the main components of a slow-neutron time-of-flight spectrometer has been developed. This sodium aluminoborate glass containing 73 mole per cent B_2O_3 and 8.0 mole per cent Ce was melted under highly reducing conditions in a series of cerium activated very high boron containing glasses. This glass is water white with very high light transmittance for wave lengths greater than 3800 Å. It has a neutron detection efficiency which is 25-30 per cent greater than any other known glass scintillator in the energy range of 10^2 to 10^4 ev and is considerably better than any other type of detector.

It was found that the neutron pulse height increased with increasing cerium content up to a maximum and then decreased with further increases in the cerium content. The molar content of cerium required to obtain a maximum pulse height for each B_2O_3 concentration increased linearly with the increase in the B_2O_3 content. However, the maximum pulse height decreased gradually with the B_2O_3 content from 17.0 arbitrary units at 55 mole per cent to 6.5 at 73 mole per cent. This lower pulse height is still considerably above the photomultiplier noise at room temperature.

The Coordination of Boron in B_2O_2 Glass

By *Scott Anderson,* The Anderson Physical Laboratory, Champaign, Ill.

The published atomic radial distribution curves for B_2O_3 glass derived from X-ray scattering show that certain peaks are uniformily ignored. The author stated

*Work performed under the auspices of the U. S. Atomic Energy Commission.

that X-ray scattering data should never be interpreted as proving that boron is 100 per cent triangularly coordinated by oxygen in pure B_2O_3 glass. This interpretation has failed to receive justification by the more recent work of Milberg and Meller. They have shown that the basic structure of the glass is not altered by the addition of water. Therefore, the small amount (10-15 per cent) of tetrahedral coordination found in the pure B_2O_3 glass cannot be attributed to water.

Similar conclusions were reached from examination of the infrared absorption spectra. This spectra was superior to X-ray scattering for the detection of small amounts of short range order in the midst of a great amount of long range disorder. The spectra of B_2O_3 glass determined by Moore and McMillan, Jellyman and Proctor, Parsons and Milberg, and the author were reviewed. It was pointed out that all the investigators whose spectra of B_2O_3 glass were of varying degrees of attested dryness showed certain absorption bands that could not be explained on the basis of 100 per cent triangular coordination of boron by oxygen. These same bands were enhanced in the soda-borate glasses. Because it was well established that the tetrahedral coordination of B increased with the addition of small amounts of soda, it appeared certain that these bands were related to tetrahedrally coordinated boron in even the purest B_2O_3 glass. Quantitative calculations placed the amount of tetrahedrally coordinated B between 8 and 12 per cent.

Moreover, Silver has shown that wet B_2O_3 glass may have as much as 5 per cent of the borons tetrahedrally coordinated from nuclear magnetic resonance studies. From the conclusion of Milberg and Meller it was concluded that an equal amount would be so coordinated in completely dry B_2O_3 glass. It was pointed out that none of the nuclear magnetic resonance data has been amenable to unequivical interpretations.

The author concluded that no one has presented X-ray scattering data, or nuclear magnetic resonance data, or infrared absorption spectra which show B_2O_3 glass to be 100 per cent triangularly coordinated. Moreover, all such data presented to date submit to an interpretation of from 5 to 12 per cent tetrahedral coordination much more readily than the 100 per cent triangular coordination usually forced out of the data.

GLASS PLANT INSTRUMENTATION

(*Continued from page* 22)

fuel set-point, fuel-air ratio, gas flow, combustion air flow, oxygen, and furnace pressure. Draft indicators, an alarm annunciator, and a clock are mounted along the top and the cutout in the center bottom of the panel

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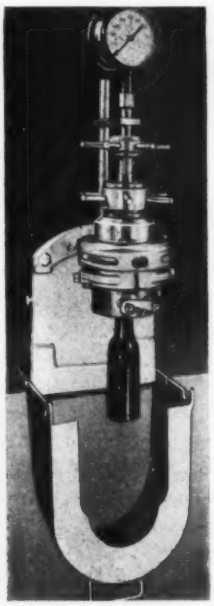

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GLASS FORMATIONS

(*Continued from page* 28)

Morey and Merwin comment that the melting point of the orthoborate is remarkably low and that it can be obtained as a glass in small quantities. They point out that the system Na_2O-B_2O_3 stands in marked contrast to the system Na_2O-SiO_2 in which the incongruent melting point of the ortho compound is higher than that of the meta compound and the tendency toward crystallization increases regularly with increasing content of Na_2O.

2. Complexity of the Melt

The principle of complexity is widely practiced in the manufacture of glazes and enamels. The use of a large variety of oxides and fluorides lowers the concentration of those constituents which participate in the formation of the primary phase. As a rule complexity also lowers the liquidus temperature so that it is not always possible to separate both effects.

3. Reduction of the Defect Concentration of the Primary Phase

This principle which is the outgrowth of our new approach to the kinetics of melting, glass formation, and nucleation shall be discussed in detail in the following chapters.

FILAMENT WINDING

(*Continued from page* 33)

Where close electrical control is necessary, the interferometer becomes an invaluable tool in fabricating radomes and nose cones. The thickness of the part wall can be held to within ± 1 electrical degrees at

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operating frequency. A wall with this electrical consistency is possible only with the resin-to-glass ratio, accurate fiber placement, interferometry and close physical tolerances.

Boresight correction, another aspect of radomes and nose cones, is being improved by the use of filament winding-interferometry techniques. By correlating range boresight results and the known parameters of radome materials, standard corrections can be ground into the mandrel, becoming an integral part of the shell. Programs have been correlated to the point where range boresight corrections have been eliminated.

Conclusion

Many further improvements have been, and are being, made in the area of filament winding, both in process and in materials. Extensive research has yielded processes by which phenolics and silicones can be utilized for high-temperature applications. To date, polyester and epoxy resins have been most commonly used.

Variations of other standard materials are also being developed for special applications. Quartz, asbestos and ceramics are being studied as filament materials (heretofore, normally glass). Continuous studies of roving end count, void content, cure cycles, resin content and roving tension are being conducted to determine their physical and electrical qualities.

Table I

COMPARISON OF GLASS-REINFORCED PLASTICS

Property	Filament Wound (Glass Roving)	Hand Lay-Up (Glass Cloth)
Interlaminar shear strength, psi x 1000	1-2	2-3
Bearing strength, psi x 1000	35-50	30-40
Tensile modulus, psi x 10^6	5-10	2-3.5
Ultimate tensile strength, psi x 1000	55-200	45-55
Density, lb/cu. in.	0.078	0.065
Flexural modulus, psi x 10^6	5-10	3-3.5
Ultimate flexural strength, psi x 1000	40-100	50-80
Polyester resin, % by weight	10-25	30-40
Compressive modulus, psi x 10^6	4-7	3-3.5
Ultimate compressive strength, psi x 1000	40-100	35-50

Through continued research and development, filament winding will become an even more important aspect in the fabrication of radome and missile nose cones.

OSCAR G. BURCH

(*Continued from page* 14)

in chemical engineering in 1927 and his Master of Science Degree in chemistry in 1929 from Washington University. After graduation he first went to work as a sales engineer for Western Electro-Chemical Co. in San Francisco.

In 1930 he ventured into business for himlself as manufacturer-owner of the Whitex Chemical Co. The next year Owens-Illinois hired him to do research in chemistry at Alton, Illinois.

He established a general research department in Toledo in 1937 and was made director of research in 1946. Four years later he was elected Vice President in charge of engineering and research.

Mr. Burch joined the American Ceramic Society in 1938 and was made a fellow in 1944. He served as vice chairman of the glass division (1945-46), chairman (1946-47) and trustee (1953-56), and was a member of the division's standards committee in 1941-42.

He was elected President of the American Ceramic Society for the year 1959-60. He is also a member of the American Institute of Chemical Engineers, the American Institute of Physics and the Society of Glass Technology of England.

In spite of his modesty and reluctance to talk about himself, Mr. Burch's accomplishments and his company's confidence in him speak for themselves. That he has won the 1961 Toledo Glass and Ceramic award is a well deserved tribute and a sincere expression of the deep respect and high regard which the industry holds for him and for his dedication to research in glass manufacturing.

INVENTIONS AND INVENTORS

(*Continued from page* 45)

The problem has been solved by attaching horse-shoe shaped heat abstractor members of relatively high thermal capacity compared to an extremity portion of the mold at their inboard extremities only to the outside lateral faces of the mold extremities. The horse-shoe shaped heat abstractor members are so constructed and arranged as to provide a space between each pointed mold extremity and its attached heat abstractor member.

Separating the heat abstractors from the pointed mold extremities minimizes thermal conduction between the heat abstractors and the mold, especially at the mold extremities where the extremities of the glass sheets are supported. The proximity of the heat abstractor members adjacent the pointed glass sheet extremities provides sufficient thermal ballast to retard the softening of the pointed glass sheet extremities during the heating phase of the bending cycle. Furthermore, since the heat abstractor members are separated from the pointed mold extremities, a greater proportion of the surface is exposed than in earlier structures wherein they were continuously attached to the mold extremities. Hence, heat abstractors constructed according to the present invention cool more rapidly between heating cycles and operate more efficiently to retard glass tip heating than earlier devices.

There were three claims and the following references cited in this patent.

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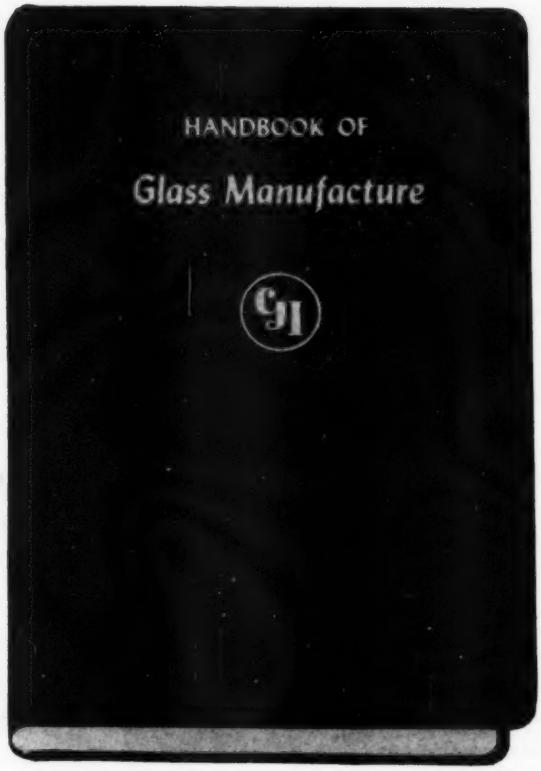

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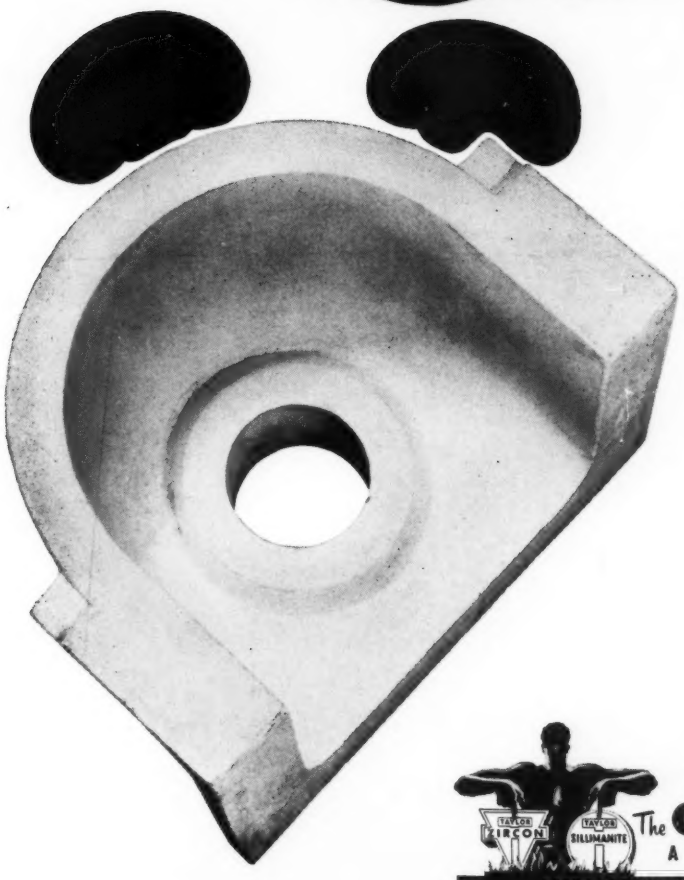

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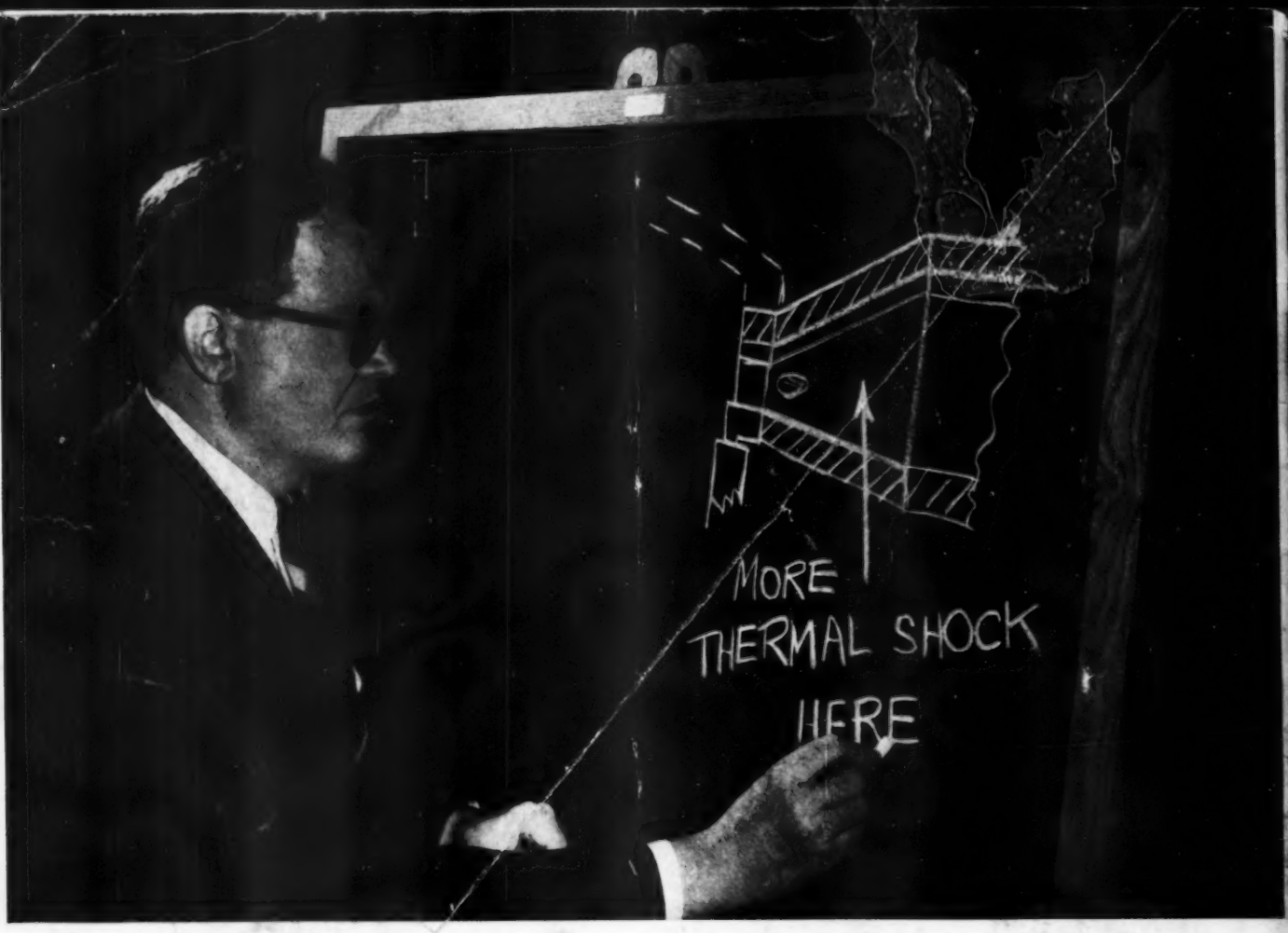

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